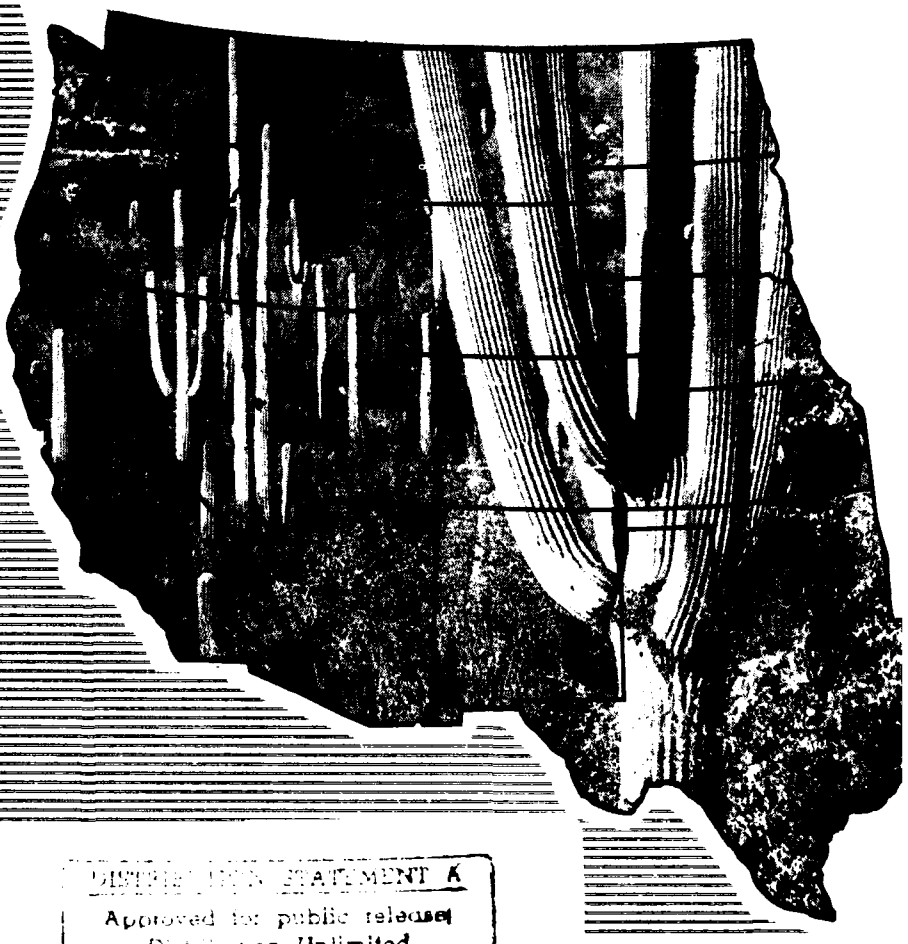
Department of the Army
Assistant Secretary of the Army
Research, Development and Acquisition
Washington, D.C. 20310-0103

ARMY SCIENCE BOARD

Report of the Ad Hoc Subgroup on

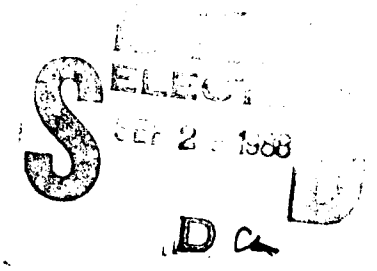
Water Supply and Management on Army Installations in the Western United States



February 1988

(4)

This report is a product of the Army Science Board (ASB). The ASB is an independent, objective advisory group to the Secretary of the Army and the Chief of Staff, Army. Statements, opinions, recommendations, and/or conclusions contained in this report are those of the Ad Hoc Subgroup on "Water Supply and Management on Army Installations in the Western United States," and do not necessarily represent the official position of the United States Army or the Department of Defense.



UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: Army Science Board (ASB) Report of the AdHoc Subgroup on Water Supply and Management on Army Installations in the Western United States	5. TYPE OF REPORT & PERIOD COVERED: Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Dr. Dennis Horn (Chairman) Dr. Downey Brill (Continued on Reverse)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Army Science Board OASA (RDA) Washington, DC 20310-0103	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Army Science Board OASA (RDA) Washington, DC 20310-0103	12. REPORT DATE: Feb 1988 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*: HQUSACE Strategic Initiatives Branch (CECW-RS) 20 Mass. Ave., NW Washington, DC 20314-1000	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Army Ammunition Plant (AAP), Army Depot (AD) Architect and Engineer Firm (AE), Army Material Command (AMC), Army Regulation (AR), Army Science Board (ASB), Construction Engineering Research Laboratory (CERL), Chief of Engineers (COE), Continental United States (CONUS), Director of Engineering and Housing (DEH), Department of Defense (DOD), US Department of Energy (DOE), (Continue on Reverse)

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report provides information on the availability of fresh water in the Western United States, which is a critical factor in installation operation, expansion planning, and future stationing decisions. The report presents current and potential water issues, water resources of the Western United States, Western Army Installations (general observations and key factors), issues, findings, and recommendations.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED
SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

7. Authors (continued)

Ms. Frances J. Laidlaw
Dr. James Smith
Dr. John Knapp
Honorable Harrison Schmitt
LTG Charles J. Simmons (USA Ret.)
Mr. Larry Storch
Mr. James Waddell
Mr. Charles Sargent

19. Key Words (continued)

Department of Justice (DOJ), Engineer Manual (EM), Executive Order (EO), Engineer Officer Advance Course (EOAC), Engineer Officer Basic Course (EOBC), Engineering Topographic Laboratories (ETL), Engineer Regulations (ER), Forces Command (FORSCOM), Government Owned Contract Operated Army Ammunition Plants (GOCO AAP), General Service Agency (GSA), Ground Water (GW), Hydrologic Engineering Center (HEC), Headquarters Department of the Army (HQDA), Headquarters US Army Corps of Engineers (HQUSACE), In Progress Review (IPR), Institute for Water Resources (IWR), Judge Advocate General (JAG), Major Army Commands (MACOM's), Military Construction Army (MCA), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), Operations and Maintenance (O&M), Proving Grounds (PG), Research and Development (R&D), Surface Water (SW), Technical Manual (TM), Terms of Reference (TOR), Training and Doctrine Command (TRADOC), US Department of Agriculture (USDA), US Department of the Interior (USDI), US Environmental Protection Agency (USEPA), US Geodetic Survey (USGS), and Waterways Experiment Station (WES).

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP ON WATER SUPPLY AND MANAGEMENT ON ARMY INSTALLATIONS IN THE WESTERN UNITED STATES

FEBRUARY 1988

STUDY SPONSOR:

LTG E. R. HEIBERG, III
CHIEF OF ENGINEERS, U.S. ARMY

TABLE OF CONTENTS

APPENDICES

TABLE 1
ARMY SCIENCE BOARD
AD HOC SUBGROUP

STUDY CHAIR

Dr. Dennis R. Horn
Assistant Professor
Department of Civil Engineering
University of Idaho
Moscow, ID

Dr. E. Downey Brill, Jr.
Professor of Civil Engineering
& Environmental Studies
University of Illinois at
Urbana-Champaign
Urbana, IL

Ms. Frances J. Laidlaw
Strategic Planner
ARA Manufacturing Company
Grand Prairie, TX

Dr. James Smith
President of Infrastructure
Group
CRS Sirrine Inc.
Houston, TX

Dr. John W. Knapp
Dean of Faculty
Virginia Military Institute
Lexington, VA

Honorable Harrison Schmitt
Private Consultant
Albuquerque, NM

LTG Charles J. Simmons (USA Ret.)
Private Consultant
Springfield, VA

Mr. Lawrence Storch
Storch & Brenner
Washington, DC

DEPARTMENT OF THE ARMY (DA)

HQDA SPONSOR

LTG Elvin R. Heiberg, III
Chief of Engineers, US Army
CG, USA Corps of Engineers
Washington, DC

OASA (RDA) CONGNIZANT DEPUTY

COL. Richard E. Entlich
Executive Director
Army Science Board
Office of the Assistant Secretary
of the Army (RDA)
Washington, DC

HQDA SENIOR ADVISOR

Mr. William L. Robertson
Deputy Chief Counsel
Office of the Chief of Engineers
Washington, DC

HQDA STAFF ASSISTANTS

Mr. James Waddell
Mr. Charles Sargent
Office of the Chief of Engineers
Washington, DC

TABLE 2
MEETINGS AND SITE VISITS •

DATES	LOCATION	PURPOSE
26-27 Feb 87	Springfield, VA	Organizational and introduction meeting. Headquarters United States Army Corps of Engineers (HQUSACE) and Chief of Engineers (COE) element presentations of functions and problem overview.
6-7 Apr 87	Ft. Bliss, TX	Site visit and briefing by installation staff, State engineers, and local governments on water supply.
1-3 Jun 87	Ft. Carson, CO. Ft. Ord, CA.	Site visit and briefing on water supply by Ft. Carson and Ft. Ord, installation staff and from Department of Justice, State engineers, and local governments.
17-18 Aug 87	Waterways Experiment Station (WES), Vicksburg, MS	Obtain overview of Research and Development programs for WES and Construction Engineering Research Laboratory (CERL).
23 Sep 87	Ft. Drum, NY	Site visit and briefing by installation and North Atlantic Division staff.
18 Oct 87	Ft. Bragg, NC	Study status meeting on issue formulation and report assignments.
9-13 Nov 87	Ft. Hood, TX Ft. Sill, OK Ft. Irwin, CA	Headquarters Department of the Army (HQDA) Staff Assistants' visit to interview Directorate of Engineering and Housing staff on water supply matters and obtain check on questionnaire.
14-15 Dec 87	Alexandria, VA	Issue consolidation report writing, and In Progress Review briefing.
7-9 Jan 88	Moscow, ID	Report organization and writing session.
8-9 Feb 88	Alexandria, VA	Final review and editing session.
14 Mar 88	Washington, DC	Presentation of report to Study Sponsor.

•All Army Scince Board meetings were announced in the Federal Register as open to the public. Except for 9-13 Nov 87 (site visits by HQDA Staff Assistant only) and 14 March 88 presentation (Chair and HQDA Staff Assistant only)

i. EXECUTIVE SUMMARY

Water is a strategic resource for the Army. It is essential for industrial processes, military operations, and installations quality of life. This statement applies to all Army facilities throughout the United States, but is especially pertinent to the Western installations located in arid and semi-arid areas. There is an array of water issues, both current and potential, facing installation commanders at many western facilities.

- Throughout the 17 Western States, nearly all surface waters have been allocated for use, making it increasingly difficult for the Army to increase its allotments.

- Ground water throughout many areas of the West is being extracted at a faster rate than the aquifers can be recharged.

- Contamination or degradation of both surface and ground water is occurring or being threatened in large areas of the West.

- There is an increasing concern for the natural environment and to improve the quality of western waters and habitats.

- A wide range of institutional arrangements govern water supply relationships between western Army installations and local, State, and Federal Government entities.

In summary, availability of fresh water in the Western United States is increasingly a critical factor in installation operation, expansion planning, and future stationing decisions. Existing and potential Army water supplies in the West are more and more threatened by pollution, overusage, competition, and waste. Engineered solutions for ensuring an adequate water supply to installations will be expensive, technically complicated, and politically difficult to accomplish and administer.

Critical findings of the Study Group are as follows:

- No appropriate legal strategy to deal with current and future water rights issues;

- Inadequate management and conservation of current resources;

- Little planning for the future water needs of the Army;

- Existence of barriers in cooperative working relations between the Civil Works and Military Construction within the USACE that hinder good water planning;

- Inconsistent levels of personnel expertise at the different USACE district and division offices, Major Commands (MACOM's), and Installations; and

- Private contractors with vastly different skill and experience levels used for installation studies.

Issues and Recommendations

Issue 1: Water Rights and Legal Policy

Rec. 1.1: DA should adopt a new policy statement regarding water rights issues and the Army's responsibility to respond to State water laws.

Rec. 1.2: DA should adopt a policy that clearly defines the organizational responsibility for dealing with water rights legal issues.

Issue 2: Water Supply Planning

Rec. 2.1: DA should require comprehensive water supply planning as part of the master planning process.

Rec. 2.2: DA should develop policies and funding options for installation participation in regional water planning organizations and project construction and operations.

Rec. 2.3: DA should prepare guidance for water resources planning and distribute this at the installation level throughout the Continental United States (CONUS).

Rec. 2.4: USACE should assist installations in mobilization master planning with specific attention to regional contingency water planning.

Issue 3: Water Use Management and Water Conservation at Installations

Rec. 3.1: DA should develop, implement, and enforce policies mandating installations to have a program for managing water use and conservation.

Rec. 3.2: USACE should provide model water use management and conservation programs for implementation at the installation level.

Rec. 3.3: DA should review budgeting and funding procedures to determine how cost savings from effective water management can, as a conservation incentive, be made available for installation use for other purposes.

Rec. 3.4: Installations should monitor water use and the cost of incremental use levels. Mass balance calculations should be routinely made to identify excessive use and to evaluate conservation programs.

Rec. 3.5: USACE should provide guidelines for determining an appropriate metering plan for each unique installation.

Issue 4: Institutional Impediments

Rec. 4.1: DA and USACE should define organizational roles and responsibilities in dealing with issues, especially legal issues.

Rec. 4.2: DA should ensure that its various schools and courses (Judge Advocate General, Engineer Officer Basic Course, Engineer Officer Advanced Course, Director of Eningeering and Housing, Installation Commanders, Master Planning, etc.) espouse proper water management as being essential to meet the long-term needs of the Army.

Rec. 4.3: Information transfer, including technology transfer, must be improved.

Issue 5: Research and Development

Rec. 5.1: In addition to its own efforts, DA should support research programs in other agencies, such as U.S. Department of the Interior, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S.Department of Agriculture, National Science Foundation, and U.S. Department of Energy which address general water-related R&D issues important to DA installations.

Rec. 5.2: Model studies should be undertaken for water-short installations to illustrate an assessment of water sources, capacities of facilities, and projected needs under various scenarios, including mobilization.

Rec. 5.3: Illustrative water use management and conservation programs should be undertaken at installations in water-short areas or at installations where water costs are high.

FINAL REMARKS

1. From the preceding recommendations, the following are particularly important and deserve immediate attention:

   • Findings and recommendations with relevance throughout CONUS should be applied accordingly.

   • Since some findings and recommendations are relevant to other military and government installations and property. the Army may wish to distribute the report within DOD and to other selected Federal agencies.

   • Since findings and recommendations cut across broad and functional organization lines, a team approach (inter-MACOM) should be considered as a basic part of any implementation srategy or plan.

2. The following are offered as implementation suggestions and guidance:

   • A consistent policy towards water rights issues, with well-defined lines of organizational legal responsibilities.

   • Improve the installation planning process on water supply sources and regional solutions to water problems.

   • Implement improved water use management and conservation practices at Army installations.

3. The Army should consider the following:

   • A study of installations in the Eastern United States since they may pose a uniquely different set of problems.

   • Limited consideration of water resources R&D at USACE laboratories provided a favorable overview of their capabilities, however, a more in-depth study of the USACE laboratories could be useful to USACE. This could be accomplished through the ASB's laboratory external effectiveness review process.

II. INTRODUCTION

In February 1987, the ASB was asked to empanel an ad hoc subgroup to conduct a study of water problems and research needs as they relate to Army installations in the Western United States. The Terms of Reference (TOR), in Appendix A, for this assignment included the following three major areas of investigation:

- Provide a comprehensive assessment of near and long-term water supply and management issues in the Western United States as they relate to installation planning and operations.

- Indicate promising areas of R&D that the Army should pursue to address these issues.

- Review Departmant of Defense (DOD) and DA policies on installation water supply and management, and indicate whether they are adequate to serve near and long-term needs.

The study group, chaired by Dr. Dennis R. Horn, consisted of eight members and was assisted by HQUSACE advisors and staff (table 1). The group began deliberations with an initial meeting on 26 February 1987 and continued with a series of site visits and discussion sessions throughout the following 12 months. A complete listing of these meetings is provided in table 2.

This Interim Report is organized as follows:

Section 1 Executive Summary

Section 2 Introduction

Section 3 (Study Background) documents the reasons for undertaking the study and discusses the restriction of the scope of work to the western Army installations.

Section 4 (Water Resources of the Western United States) provides background information on the hydrology and climate of the Western States; a brief history of water resources development and the role of the U.S. Army; and a general discussion of the aspects of western water law.

Section 5 (Western Army Installations) describes the location, number, and types of major western Army installations and summarizes the information obtained from site visits and questionnaires distributed to most of the installations.

Section 6 (Issues, Findings, and Recommendations) presents the key issues and recommendations of the Subgroup.

Section 7 (Concluding Remarks) provides remarks and suggestions for further study.

III. BACKGROUND

As stated in the TOR, water is a strategic resource for the Army, essential to industrial processes, military operations, and installation quality of life. This statement applies to all Army facilities throughout the U.S., but is especially pertinent to western installations located in arid and semiarid areas. The TOR requested that the study effort concentrate on western installations because of the distinctive hydrologic setting as well as legal frameworks that are different from those encountered in the East.

There is an array of water issues, both current and potential, facing installation commanders at many western facilities. Throughout the 17 Western States, nearly all surface waters have been allocated for use, making it increasingly difficult for the Army to increase its allotment to meet future needs. Existing patterns of water entitlement are certified through a process of court-ordered adjudication of water rights in a number of river basins and interstate compacts designating and defining water use for several of the large rivers. These combined factors create uncertainty over future water rights in many regions.

Ground water throughout many areas of the West is being extracted at a faster rate than the aquifers can be recharged. From Texas to Nebraska in the High Plains area, ground water levels in the Ogallala aquifer are declining from 7-10 feet per year, while withdrawal of water in California, Texas, and other states has caused significant land subsidence. With withdrawal rates in excess of recharge potential, the mining of ground water will impose a time limit on the continued extraction of water from these sources and impose dependance on new water sources.

Contamination or degradation of both surface and ground water is occurring or being threatened in large areas of the West. Salt water intrusion, caused by excessive pumping of ground water in both coastal and interior regions, has caused numerous wells to be abandoned. Human activities have resulted in pollution of surface and ground water through increased fertilizer and pesticide use, municipal and industrial wastes, contaminated mine drainage, and sediment from erosion. Many water sources of today may be impossible to use in the future without expensive treatment or rehabilitation.

Needs are changing. While pressures are mounting to develop the vast natural resources of the West, there is an increasing concern to protect the environment and to improve the quality of the West's waters and habitats for fish and wildlife. This concern is causing the traditional use of riverine wetlands for agriculture to compete with environmental preservation interests.

A wide range of institutional arrangements govern water supply relationships between western Army installations and local, State, and other Federal Government entities. In many cases, the installations are supplied by local public entities and the Army's claims must compete against other public and private uses which may have a higher peacetime priority. Thus, mission requirements, quality of installation life, and mobilization efforts could all be severely affected by drought conditions, inadequate regional planning, or increased competition from other users.

In summary, availability of fresh water in the Western United States is increasingly a critical factor in installation operations, expansion planning, and future stationing decisions. Existing and potential Army water supplies in the West are more and more threatened by pollution, overusage, competition, and waste. Engineered solutions for ensuring an adequate water supply to installations will be expensive, technically complicated, and politically difficult to accomplish and administer.

It is important that these problems be viewed in the context of the much broader issues facing all water users throughout the West. The Army is by no means a large water user. Its annual consumption is dwarfed by municipal consumption figures for the rapidly urbanizing areas of the western sunbelt, and these, in turn, are minor compared to the enormous consumptive use of western agriculture. In fact, the agricultural sector alone accounts for as much as 90 percent of the total consumptive use throughout most of the Western States, and a minor increase in irrigation efficiency could save an amount of water equivalent to the total water used by the Army each year.

The Army accordingly finds itself in a "David versus Goliath" role with the "Goliaths" of urban communities and agricultural interests having the political and economic power to continue influencing the evolution of water policy in the United States and, especially the Western States. To date, this evolution has not resulted in a clear-cut national policy towards issues such as ground water use and contamination, exportation of water across State boundaries, or the pricing of water at a level commensurate with its marginal value. Until such policy is developed, the West may continue to struggle with a depletion of its water resources and water allocation decisions that economically are far from optimal. The Army must adapt to the constraints imposed upon it by these realities.

These constraints do not imply that the Army should not continue to seek out a leadership role in the wise management and conservation of water. As "David," the Army has the ability to demonstrate, by example, the benefits to be derived through a more efficient use of water resources and the implementation of its R&D efforts in the water resources field.

USACE has long been recognized for its leading position in many areas of water resources planning and research, as evidenced by the efforts of the Institute for Water Resources (IWR), CERL, WES, Hydrologic Engineering Center (HEC), and Engineer Topographic Laboratory (ETL). Emergency water planning is already an evolving mission assigned to USACE in 1983 by Executive Order (EO) 22490, ensuring that military and essential civilian needs are met during national security emergencies. If, ultimately, a national policy and direction emerges for overall water supply and water resources management, USACE should be prepared to take an active role in the implementation of such a policy.

IV. WATER RESOURCES OF THE WESTERN U.S.

A. STUDY AREA HYDROLOGY

General

The Western United States is largely arid or semiarid with variable rainfall averaging less than 20 inches annually, and, in many cases, less than 10 inches. This "desert" condition is particularly evident when compared to the Midwestern and Eastern United States where average annual rainfall is generally double that of the Western United States. A large notable exception is the water-rich Pacific Northwest, which includes the western half of the States of Oregon and Washington, the northern half of California, north-central Idaho and western Montana.

The Western United States is an area of great contrast which bears a relationship to water availability. Altitudes vary from more than 14,000 feet above sea level to 248 feet below. Rainfall ranges from more than 100 inches per year to less than 1 inch. Temperatures are between 120 degrees F to minus 50 degrees F. The West also has both glaciers and boiling springs; the world's tallest trees and the barest desert lands; the largest and deepest river canyons; some of the purest and most mineralized water; some of the largest natural areas in the coterminous United States, some of the most developed urban regions, and the most intensively farmed lands.

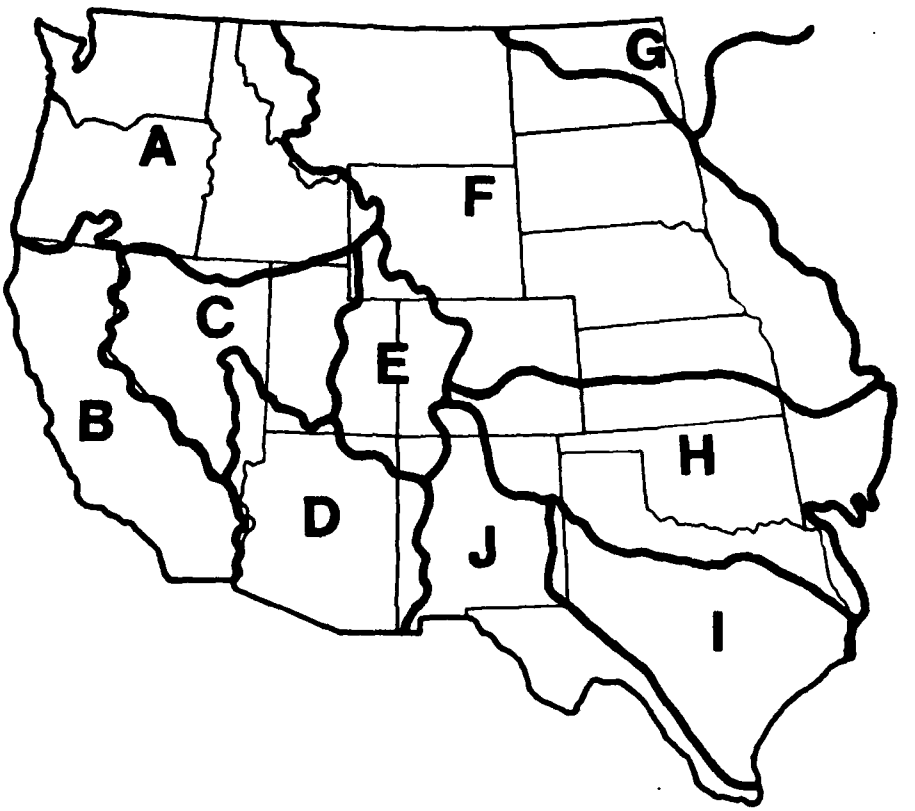
Runoff and Surface Water Development

Western rainfall patterns tend to be influenced primarily by the region's rugged topography and the storm patterns originating in the Pacific Ocean and moving westward across the United States. Orographic lifts of moist air currents result in high precipitation of more than 100 inches annually on mountain slopes facing the West. Precipitation in the higher mountains occurs mostly as snow. Snow accumulates over the winter and melts in the spring and summer, thus contributing to an uneven runoff distribution. During the period of April to July, 70 percent of annual streamflow occurs. Uneven runoff conditions and the need to transport water long distances to meet western urban and farming needs have led to major dam construction and river diversions. In fact, natural hydrologic regimes of most western streams have been altered considerably over the past 75+ years to meet the needs of developing the West.

One measure of the degree to which the available surface water resources of a region or drainage area is already developed is the consumptive water use of a region expressed as a percentage of annual renewable supply. This use is shown in table 3 for the 11 water resources regions in the study area. The location and boundaries of the water resources regions with respect to the 17 Western States making up the study area use is shown on plate 1. Consumptive water use as a percent of renewable supply (table 3, last column) represents a theoretical limit for broad water management comparison purposes. For example, 96 percent of the renewable water supply for the Lower Colorado region is shown as presently being used. The Rio Grande and Great Basin regions also show high uses of 64 and 49 percent of renewable supply, respectively. By comparison, consumptive use is less than 3 percent of renewable supply in all other (Eastern) water regions of the coterminous United States. The higher consumptive use in the Western United States can be attributed to the fact that 91 percent of the

PLATE 1

WATER RESOURCES REGIONS



A - PACIFIC NORTHWEST REGION
B - CALIFORNIA REGION
C - GREAT BASIN REGION
D - LOWER COLORADO REGION
E - UPPER COLORADO REGION
F - MISSOURI BASIN REGION
G - SOURIS-RED-RAINY REGION
H - ARKANSAS-WHITE-RED REGION
I - TEXAS-GULF REGION
J - RIO GRANDE REGION

TABLE 3

GENERALIZED WATER BUDGET - WESTERN U.S. BASINS IN BILLION GALLONS PER DAY 3/

WATER RESOURCE REGION	AVERAGE 2/ ANNUAL STREAMFLOW	ANNUAL DEPLETION OF GROUD WATER STORAGE	OFFSTREAM CONSUMPTIVE USE	NET RESERVOIR EVAPORATION	ANNUAL RENEWABLE SUPPLY	NET IMPORTS OR EXPORTS	CONSUMPTIVE USE	CONSUMPTIVE USE AS PERCENT OF RENEWABLE SUPPLY
Upper Mississippi 1/	77.6	0	1.5	.6	79.7	2.0	2.0	9.0
Sources - Red - Rainy 1/	7.2	0	.1	.4	7.7	0	.5	6.5
Arkansas - White Red 1/	56.3	3.6	9.6	1.4	63.7	0.2	11.0	17
Missouri	50.2	2.2	16.0	3.3	67.3	0.1	19.3	29
Texas - Gulf	30.7	3.1	6.5	1.8	35.9	0	8.3	23
Rio Grande	1.8	0	2.4	.8	5.0	0.1	3.2	64
Under Colorado	8.3	0	2.3	3.6	12.3	-0.6	4.0	33
Lower Colorado	2.5	2.1	7.2	3.6	11.2	-3.7	10.8	96
Great Basin	4.2	0	3.9	.2	8.3	0	4.1	49
Pacific Northwest	278	0	12.0	.6	291	0	12.6	4.3
California	62.8	1.4	25.0	.5	86.9	3.7	25.5	29

1/ Water resources region only partly within study area.
2/ Average annual streamflows are estimated from streamflow records for the period 1950-80 (US Geodetic Survey).
3/ All data from USGS Publications

total water withdrawn for irrigation occurs in the West and irrigation accounts for the vast majority of western water consumption (85 to 90 percent of all water consumed in the West).

Inherent in the highly developed nature of western surface water resources is the scarcity and the high cost of any additional surface water resource development opportunities. Additional development can also be constrained by social, political, and environmental considerations as well as economic ones.

Ground Water Resources and Use

In much of the Western United States where precipitation is sparse to moderate and diverted surface water supply is unavailable, ground water forms a vital part of the water supply. During the past several decades, ground water resources have played a sizeable role in satisfying demands for fresh water. Many cities, industries, and irrigators, as well as rural inhabitants and military installations, have depended upon ground water resources because of accessibility, good quality, and low cost of utilization. Ground water tends to be more uniformly distributed both in areal extent and capacity than surface water sources and, therefore, can be used more advantageously. However, because of the interrelationship between surface and ground water, conjunctive-management use is necessary to maximize long-term water supplies and protect ground water sources from rapid depletion. Ground water reserves can accommodate temporary periods of overdraft when necessary, but the extent to which a principal ground water reserve can be conserved and managed determines whether it is an adequate dependable supply for the future.

The estimated overall removable supply of ground water is generally abundant throughout the study area. Estimated annually available ground water supply varies from about 1.5 million acre-feet in the Lower Colorado Water Resource Region to nearly 5 million acre-feet in the Texas-Gulf and California Water Resource Regions. Widespread availability of ground water is constrained by the economic costs of pumping and treatment to improve water quality and by the water-yielding characteristics of the aquifer itself. Experience in California, Texas, and elsewhere has shown that ground water yield/development is being increasingly constrained by the adverse effects of land subsidence, increased costs associated with a gradually lowering water table, and a decreasing of water quality.

The Ogallala aquifer covers a major portion of the study area from west-central Texas and eastern New Mexico to Wyoming-South Dakota, extending beneath seen states. The Ogallala has two major distinctions: it is the largest aquifer in the world and the fastest disappearing aquifer in the world. An aquifer which may have taken 1/2 million years to develop will be mined out in some areas within 25 to 50 years. In some places the water table level of the Ogallala is dropping at a rate of 7-10 feet or more per year. Already, in some areas of the high plains of Texas, increasing irrigation costs are causing a shift to dry land farming and farm land abandonment.

Localized ground water problems also exist in every water resource region of the study area. These problems include, overdrafting, saltwater intrusion in coastal areas, increasing salinity in interior areas, decreasing water quality with increased depth of withdrawal, and contamination from man-originated sources. In addition, in some areas the lack of hydrogeological information on ground water hinders problem solving.

B. HISTORICAL SETTING

Before the European settlement of North America, Indian farmers created fields near water supplies, often within deep mountain canyons, and grew crops on river valley floodplains. As their cultures advanced, Southwestern Puebloan peoples stored water in natural catchment basins and small man-made reservoirs, and Hohokam Indians built canals. Spanish missionaries and colonists combined both Spanish and Indian conservation practices. They created reservoirs on streams which filled during the night and they irrigated their fields by day. They used retaining walls to conserve water and diverted it to patio gardens.

From its beginnings, the United States Army has contributed to the development of the West. Organized after the winning of independence, the peacetime Army was created primarily to protect and aid westward expansion. The Army contributed essential engineering skills generally lacking in the civilian population. They constructed and improved roads, built and supplied a network of forts which served as bases for military operations, conducted exploring expeditions, and provided protection from Indians. Pioneers looked to the Army for assistance in developing resources. Soldiers helped introduce farming to new frontiers, cleared lands, operated saw mills, provided assistance to travelers, and assisted with the operation of government trading posts.

Rivers served as routes of exploration and commerce and provided a source of food and water. Army explorers, Capt. Meriwether Lewis and Lt. William Clark, led an expedition up the Missouri River. They crossed the Rocky Mountains and followed the Columbia River to the Pacific, exploring Montana on their return to St. Louis. Capt. Zebulon M. Pike was dispatched to the headwaters of the Mississippi and later explored Colorado. 2nd Lt. John C. Fremont of the Corps of Topographic Engineers led an expedition to explore and map the Platte River country which was used by emigrants following the Oregon Trail. By the time of the Civil War, Army engineers had explored, mapped, and surveyed numerous routes to the West including those for the Pacific Railroad.

Irrigated agriculture produced continued expansion and stable settlement for broad areas of the West. In the 1800's, the Mormons began the transformation of the desert areas of Utah. They diverted water from small streams to soften the earth before they plowed. They built simple diversion dams and almost 1,000 miles of canals. In 1865, the Utah territorial legislature passed the first irrigation district law which authorized citizens to organize irrigation companies and levy taxes to build and maintain canals under county government supervision.

The gold rushes in California in 1849 and in Colorado in 1856 contributed to a significant increase in western population. Mining also contributed to settlement of Arizona, Idaho, Montana, and Nevada.

From 1878 to 1902, expansion of irrigation became a critical issue as speculators and residents attempted to reclaim large acreage in the desert. Land was given or sold cheaply to those who would cultivate it. In 1877, after the enactment of the Desert Land Act, settlers in California, Oregon, Nevada, and eight territories could purchase 640 acres of desert land on condition they irrigate it within three years. The Reclamation Act of 1902 provided the basis

for Federal Government construction and operation of irrigation projects. In order to establish irrigated agriculture in the desert, storage reservoirs and diversion structures were built to stabilize and distribute stream runoff. Massive volumes of water were conveyed to irrigate new farmland and/or enhance established farmland.

During the first 20+ years of the 1900's, the policy of multipurpose water resources development projects was established. In addition to irrigation, other project purposes included: flood-control and hydroelectric power with municipal water supply, general recreation, water quality control, and fish and wildlife recreation, all added under subsequent Federal legislation. The era of major Federal project development extended through the 1960's. The most significant multipurpose projects of the "big dam era" included: Hoover and Glen Canyon Dams on the Colorado River, Oroville and Shasta dams in northern California, Grand Coulee, and Bonneville Dams on the Columbia River, the mainstream system of dams on the upper Missouri River, and the Salt River Project in Arizona. In the process of development of these and other projects the planning focus at the Federal level was broadened from a project to a river basin context. Planning needs were also expanded to include intangible or noneconomic values such as fish and wildlife preservation, environmental enhancement, and aesthetic values.

It is generally recognized that new large water projects are things of the past and that water conservation and reallocation of water use are the primary alternatives for meeting future water needs. The population of the West is increasing at about twice the rate of the rest of the Nation and, as a result, the municipal sector is the fastest growing water user. In many cases, these municipal water needs encompass Army installations which may have competing water needs. In less populated areas, the Army may also be competing with agricultural and industrial water users for water supply sources that are diminishing in both quantity and quality. The degree of present interest and debate over western water problems makes apparent the opportunity for the Army to serve as an example and catalyst for improving water policies.

C. EVOLUTION OF WESTERN WATER LAW

Early settlements in the arid West were established along rivers, and settlers used water as they wanted. As water use increased in amount and location of use, conflicts arose between miners, farmers, and other users. Local water laws evolved during the 19th century and, upon statehood, were modified in State law. Federal statutes enacted to encourage homesteading and settlement of public lands also recognized and sanctioned the various systems of State water law.

Since colonial times, water law in the Eastern United States has been based on the riparian doctrine under which persons living on or owning property on the bank of a river have a right to make reasonable use of the shore and water. However, in the arid or semiarid Western States, it was frequently necessary to divert water from its source, and State constitutions and laws have adopted the doctrine of "prior appropriation." Under this doctrine, surface water rights depend on seniority of water use and geographic proximity to the water source. The first one to make beneficial use of the water has the senior right to continue to use the water and is protected to the extent of such use. Subsequent users have increasingly junior rights until all the water is used. Since water rights can be lost by nonuse, there is generally no incentive to conserve. In some States such as California, the principle of prior appropriation was superimposed on the riparian system, while in States such as Wyoming and Colorado, prior appropriation is the exclusive principle of water law.

State laws for the allocation of ground water are not generally as fully developed or as clearly defined as those for surface water. Some Western States apply the prior appropriation doctrine to ground water. Others, like Texas, apply private property doctrines similar to those for mineral and oil resources, giving landowners the right to mine and use underlying ground water.

As settlement of public lands proceeded, the Federal Government reserved large portions of the public domain for Indian and military reservations, national forests, and parks. The Federal and Indian-reserved water rights doctrine recognized the implied intent of the Government to reserve water in sufficient quantity to fulfill the purposes of the reservations. Regardless of when the water was first put to use, the priority for both ground and surface water is from the date on which the land was reserved. This is inconsistent with State systems of water rights based on the prior appropriation doctrine. The perceived threat of Federal reserved water rights to private water rights held under State law has resulted in numerous statewide water rights adjudications which require the government to quantify all Federal reserved water rights.

A recent development occurred during the drought of 1976-77. A Federal water bank in California facilitated the transfer of water within the agricultural sector. Also there have been isolated negotiated transactions, transfers to and withdrawals from organized water banks and transactions facilitated by established water markets.

Another recent development involves increasing marketing of water rights. In 1982, the Supreme Court established the right to use water as an article of commerce, not to be unreasonably restricted by the States. The same year, California amended its water code to establish conservation and subsequent sale of the conserved water as a beneficial use. It directed State agencies to encourage voluntary transfers of water and water rights. And the Papago Indian Water Rights Settlement of 1982 and the Fort Peck-Montana Compact of 1985 included provisions for off-reservation water marketing.

V. WESTERN ARMY INSTALLATIONS

A. INTRODUCTION

Within the 17 Western States study area, 30 major Army installations were identified. The 30 major installations are listed in table 4 and their location is shown on plate 2. Site visits were made to 6 installations in the study area and water supply questionnaire responses were received from a total of 24 installations.

Summary of Site Visits

The Ad Hoc Subgroup visited Ft. Bliss, Ft. Carson, and Ft. Ord in order to develop an understanding of the missions, roles, and responsibilities of the installations vis-a-vis USACE and other Federal, State, and local agencies. The group also examined/discussed the installations' planning processes, conservation programs, utilities infrastructure, and any other water supply and management concerns brought up by the installations. It was not the study group's purpose to resolve any specific issues at the installations visited. The Army Staff assistants also visited Ft. Hood, Ft. Sill, and Ft. Irwin. The six installations were selected on the basis of differing State, MACOM, and/or water issues problems. No United States Army Material Command (AMC) installations were visited; however, DEH personnel from White Sands Missile Range participated in the Ft. Bliss meeting and a representative sample of AMC installations responded to the questionnaire.

Although not in the study area, Ft. Drum, New York, was also visited by a limited contingent of the group (Horn, Knapp and Waddell). The installation's massive expansion program was reviewed since it utilized some new and unorthodox (for the Army) utilities infrastructure financing arrangements with municipalities and the private sector.

General Observations

Each installation is confronted with a unique set of external and internal forces that shape its water supply and management issues. The site visits confirmed much of the group's initial views of the issues. They are complex, sensitive, and widespread. The issues defy simple categorization as technical, legal, etc. They are crosscut by politics, economics, future force structures, sociology, historical precedence, competing interests, and the incongruent roles (or lack of presence) of the various DA, DOD, Federal, State and local agencies dealing with water issues.

Although water conservation was considered a good idea by all installations, few had the technical means or command emphasis to have an accountable program.

Key Factors Shaping the Issues by Installation

Ft. Bliss lies in Texas and New Mexico and is primarily supplied by aquifers lying under these two States and Mexico. Legal, geopolitical, and competing interests (agricultural through the Rio Grande Compact Commission) are the overriding factors leading to problems that were exasperated by the Army's lack of clear-cut roles and responsibilities in the legal area.

PLATE 2

INSTALLATION LOCATIONS

TABLE 4

WESTERN ARMY INSTALLATIONS

NAME	LOCATION	EFFECTIVE POPULATION	TYPE	MAJOR UNIT-ACTIVITY-FUNCTION
1. Fort Carson	Colorado Springs, CO	24,108	FORSCOM	4th Infantry Division
2. Fort Hood	Killeen, TX	43,505	FORSCOM	1st Calvary Div & 2nd Amored Div
3. Fort Sam Houston	San Antonio, TX	17,776	FORSCOM	Medical Training HQ
4. Fort Lewis	Tacoma, WA	30,570	FORSCOM	9th Infantry Division
5. Fort Ord	Seaside, CA	20,493	FORSCOM	7th Infantry Division
6. Fort Irwin	Barstow, CA	5,720	FORSCOM	National Training Center
7. Fort Riley	Junction City, KS	23,329	FORSCOM	1st Infantry Division
8. Fort Bliss	El Paso, TX	27,501	TRADOC	Air Defense Center & School
9. Fort Leavenworth	Leavenworth, KS	6,400	TRADOC	Command & General Staff College
10. Fort Sill	Lawton, OK	29,241	TRADOC	US Army Field Artillery Ctr&Sch
11. Umatilla Depot Activity	Hermiston, OR	288	AMC (AIF)	Storage Depot
12. Hawthorne Army Ammunition Plant	Hawthorne, NV	832	AMC (GOCO)	Storage-Ammo
13. Kansas Army Ammunition Plant	Parsons, KS	1,156	AMC (GOCO)	Production-MISC Ammo
14. Lone Star Army Ammunition Plant	Texarkana, TX	2,076	AMC (GOCO)	Production-Misc Ammo
15. Longhorn Army Ammunition Plant	Marshall, TX	972	AMC (GOCO)	Production-Misc Ammo
16. Riverbank Army Ammunition Plant	Riverbank, CA	277	AMC (GOCO)	Production-Projectiles
17. Dugway Proving Ground	Dugway, UT	1,575	AMC (RDTE)	R&D Test Center
18. White Sands Missile Range	White Sands, NM	7,023	AMC (RDTE)	R&D Test Center
19. Yuma Proving Ground	Yuma, AZ	1,393	AMC (RDTE)	R&D Test Center
20. Fort Huachuca	Sierra Vista, AZ	11,620	USISC	Comm CMD & Intelligence School

TABLE 4 (CONT.)

NAME	LOCATION	EFFECTIVE POPULATION	TYPE	MAJOR UNIT-ACTIVITY-FUNCTION
21. Corpus Christi Army Depot	Corpus Christi, TX	N/A	AMC (AIF)	N/A
22. McAlester Army Ammunition Plant	McAlester, OK	98	AMC (AIF)	Storage-Ammo
23. Navajo Depot Activity	Flagstaff, AZ	6	AMC (AIF)	Storage
24. Pueblo Depot Activity	Pueblo, CO	916	AMC (AIF)	Logistics Depot
25. Red River Army Depot	Texarkana, TX	6,422	AMC (AIF)	Logistics Depot
26. Rocky Mountain Arsenal	Denver, CO	256	AMC (AIF)	Production-Chemical
27. Sacramento Army Depot	Sacramento, CA	3,882	AMC (AIF)	Logistics Depot
28. Sharpe Army Depot	Stockton, CA	1,705	AMC (AIF)	Logistics Depot
29. Sierra Army Depot	Herloug, CA	1,025	AMC (AIF)	Logistics Depot
30. Tooele Army Depot	Tooele, UT	4,002	AMC (AIF)	Logistics Depot

Source of data: DOD Base Structure Report for FY 86

Ft. Carson believes that they do not have a water problem. They purchase most of their water from the city of Colorado Springs, through a General Services Administration contract, at one of the highest rates paid by the Army. Since Colorado is an adjudicatory State, legal forces are key drivers in any water issue. Ft. Carson has five pending court cases for change of use.

Ft. Ord, located on the California coastline and dependent on ground water, is faced with salt water intrusion and competing interests (municipal and agricultural). Lack of water management on the part of the installation compounded problems in the past; however, it recognizes the importance of becoming a participant in regional water supply planning, management, etc. The installation is making progress and will continue to do so as long as productive participation is not dependent on the Installation Commander obligating the Army beyond his authorities.

Ft. Hood, Texas, is probably the best situated of the installations visited. It is located within one river basin and deals primarily with one local water control district. Its raw water supply is from a USACE multipurpose project and local municipalities provide water treatment. It presently has few competing interests but a conceivable threat in the future could come from the Dallas/Ft. Worth metropolis or agriculture as the regional ground water (Ogallala aquifer) diminishes. Should this occur, the fact that Ft. Hood has a congressionally mandated storage right in a USACE reservoir may not be enough to protect the installation.

Ft. Sill is totally dependent on the city of Lawton, Oklahoma, for its water supply needs. It does not own any water rights or own or control any surface storage. At the present time, Lawton cannot meet the peak demands of its customers because of overextended water supply infrastructure. The city has plans to upgrade and enlarge its facilities but is having difficulties securing the approval of voters required, for new bond issues. Local politics and popular support are the key drivers in Ft. Sills water issues and, therefore, the installation's ability to meet current and future water demands is unknown.

Ft. Irwin, California, unlike any other installation visited, is in total control of its water supply sources. Unfortunately, it is a non-renewable resource. The installation is pumping its water from two aquifers with a twenty year life expectancy (2008) and plans to pump a third (requires an FY 88 Military Construction Army project) that is said to provide another 40-year supply (2048). After that it must go elsewhere to find water in one of the most arid regions of the country. Ft. Irwin uses 250 gallons per capita per day, the highest usage in the study area. Water management will be a key factor in shaping the economic feasibility of operating Ft. Irwin in the next century.

B. SUMMARY OF RESPONSES TO INSTALLATION QUESTIONNAIRE

General

Questionnaires were mailed to a total of 30 major Army installations in the 17 Western States. A copy of the questionnaire is inclosed in Appendix C. By MACOM the installations were: U.S. Army Forces Command (FORSCOM) - 8 installations; U.S. Army Training and Doctrine Command (TRADOC) - 3 installations; AMC - 20 installations, of which 5 were Government-Owned Contractor-Operated Army Ammunition plants (GOCO AAP's). Responses were obtained from a total of 24 installations. Responses cover 7 FORSCOM installations, 3 TRADOC installations, and 14 AMC installations. In general, the FORSCOM and TRADOC

installations account for the vast majority of troops. The responses provide a reasonable geographic distribution reflecting a cross-section of Western United States water resource conditions. The quality of the responses received varied greatly between installations and, therefore, detailed specific conclusions would tend to be questionable. The responses were used to draw only generic conclusions in keeping with the broad, general appraisal scope of this ASB study. A comparison was made of installation responses by question; results are presented in Appendix B. Conclusions were developed for each question based on these comparisons.

QUESTION #1 - What is your installation's source of water supply?

RESPONSE #1 - Only five of the installations reported purchasing water from outside sources. The outside sources involved both ground and surface water. One of these installations owned surface water rights and contracted for treatment of its water. Ten installations reported self-supplied ground water; four reported a combination of self-supplied ground water and surface water; five reported self-supplied surface water; and one reported use of self-supplied unregulated streamflow.

QUESTION #2 - What is your installation's water use?

a. Average for last three years.
b. Average monthly use.
c. Peak for last three years.

RESPONSE #2 - Average daily water use varied from a high of 7.86 million gallons per day (Mgal/d) at Ft. Lewis, Washington, to 0.179 Mgal/d at Kansas Army Ammunition Plant, Kansas. Peak use as a ratio of average daily use varied from over 4.5 times daily use for Hawthorne AAP, Nevada, to about 1.4 times daily use for Ft. Leavenworth, Kansas. In general, the larger installations had the smallest variance between average daily use and peak use. Also, as might be expected, installations with a high percentage of family housing and landscape irrigation tended to have a higher peak use when compared to average daily use. Responses on average use were used to develop the following tabulation (table 5) and show a comparison of maximum peak flow to average daily flow.

QUESTION #3 - (For installations using ground water) - Is ground water depletion a problem? Does ground water source have a limited life?

RESPONSE #3 - Of the 14 installations reporting ground water as a full or partial source of water supply, 7 reported definite or possible problems with ground water depletion and corresponding limitations on aquifer life. Some depletion also related more to quality more than quantity.

QUESTION #4 - What is your current water supply cost? See table 6.

TABLE 5

WATER USE

	#2a Average Daily Use Mgal/d	#2b Highest Peak in Last 3 Yrs Mgal/d	Maximum Peak Compared to Average Daily Flow
1. Ft. Carson, CO	2.7	Unknown	Unknown
2. Ft. Hood, TX	6.68	16.989	2.54
3. Ft. Sam Houston, TX	3.4	10.3	3.03
4. Ft. Lewis, WA	7.8609	16.997	2.16
5. Ft. Ord, CA	5.264	10.954	2.09
6. Ft. Riley, KS	3.622	8.400	2.32
7. Ft. Bliss, TX	4.26	10.311	2.42
8. Ft. Leavenworth, KS	2.8	3.857	1.38
9. Ft. Sill, OK	3.133	6.759	2.16
10. McAlester AAP, OK	0.730	1.676	2.29
11. Navajo Depot Acty, AZ	.093	.940	10.11
12. Red River AD, TX	1.627	2.714	1.67
13. Rocky Mountain, Arsenal, CO	0.214	0.851	3.97
14. Sacramento AD, CA	.359	No data	-
15. Sharpe AD, CA	No data	1.071	-
16. Sierra AD, CA	1.100	2.500	2.27
17. Hawthorne AAP, NV	1.068	4.849	4.54
18. Kansas AAP, KS	0.179	0.4585	2.56
19. Lone Star AAP, TX	0.644	Unknown	-
20. Longhorn AAP, TX	.432	.886	2.05
Dugway PG, UT	2.01 1/	3.4	1.7
	.32 2/		11.3
22. Tooele, AD UT	1.065	3.323	3.12
23. White Sands Missile Range, NM	1.7337	4.500	2.59
24. Yuma PG, AZ	0.83108	Unknown	-
25. Corpus Christi	1.5	4.5	2.1

1/ Daily average summer season.

2/ Daily average winter season.

TABLE 6

SUMMARY OF WATER SUPPLY COSTS

	Source of Water	$/1,000 gal. Externally Supplied	$/1,000 gal Self-Supplied
1. Ft. Carson, CO	Local Utility - Comb. of Sources	$1.12	-
2. Ft. Hood, TX	Local Utilities - Surface Water Reservoirs	$0.23 & $0.52	-
3. Ft. Sam Houston, TX	Ground water - Edwards Aquifer		$0.21
4. Ft. Lewis, WA	Comb. Surface & Ground Water		$0.0604
5. Ft. Ord, CA	Ground Water -		$0.125
6. Ft. Riley, KS	Ground Water -		$0.63
7. Ft. Bliss, TX	Ground Water: Self-supplied 70% Outside 30%	$0.6664	$0.45
8. Ft. Leavenworth, KS	Ground Water		$0.4597
9. Ft. Sill, OK	Local utility - Reservoirs	$0.26	
10. McAlester AAP, OK	Reservoir		$0.80
11. Navajo Depot Act, AZ	Ground Water-		$1.29
12. Red River AD, TX	Reservoir		$0.60
13. Rocky Mountain Arsenal, CO	Local utility	$0.4	
14. Sacramento AD, CA	Local Utility	$0.377	-
15. Sharpe AD, CA	Ground Water-		$0.61
16. Sierra AD, CA	Ground Water-		$1.33
17. Hawthorne AAP, NV	Comb. Ground & Surface Water		$0.385
18. Kansas AAP, KS	Unregulated Streamflow		$1.6729
19. Lone Star AAP, TX	Water from RRAD, TX (#12)	$0.67264	
20. Longhorn AAP, TX	Surface Water		No data
21. Dugway PG, UT	Ground Water		$0.743
22. Tooele AD, UT	Ground Water		$0.70
23. WSMR, NM	Ground Water	$1.24	
24. Yuma PG, AZ	Self-supplied Ground Water + Bottled Water	$527.91	$1.11
25. Corpus Christi AD, TX	Surface and Reservoir	$0.54	$0.00

QUESTION #5 - What percentage of total water consumption is used for family housing and for irrigation?

RESPONSE #5 - The majority of installations (13) report family housing use as 18 to 30 percent of overall water use. Two report 50-55 percent family housing use, one 85 percent, three less than 5 percent, and three reported distribution unknown. There is a discernible pattern of use for irrigation. Golf course irrigation generally involves wastewater or non-potable well water.

QUESTION #6- What are installation's most pressing water supply problems?

RESPONSE #6 - Most pressing current problem reported is inadequate distribution system (14 installations). Six reported inadequate water treatment facilities. Quality of water supply is a problem at four installations. One installation reported that water supply source does not meet firefighting criteria. Two installations reported no problems.

QUESTION #7 - What constraints do installations have on water supply expansion?

RESPONSE #7 - Four installations report no constraint on water expansion. Seven indicate water treatment plant constraint (including one outside source). Other constraints are inadequate quality or quantity of water supply source (6), distribution system problems (including storage of treated water) at (7), inadequate firefighting water (3), and economic (1)

QUESTION #8 - What measures or programs are employed to conserve water?

RESPONSE #8 - Four (4) installations reported having no conservation programs. Ten (10) reported programs consisting primarily of voluntary water restrictions with some policing of excessive irrigation. Others report limited metering, recycling wash facilities, use of treated wastewater effluent for golf course, irrigation etc., use of water-restricting devices (shower heads, etc.), and leak detection programs. In general, conservation programs tend to be on an as needed basis to fit water shortage situations. One installation reported a detailed conservation program to fit increasing drought severity.

QUESTION #9 - How is effectiveness of water conservation measures or programs determined?

RESPONSE #9 - Most installations reported a review of water use by comparison with past average flows, but no good program to gauge how well any conservation policy may work. Lack of meters is a constraint on monitoring. Some visual inspection of irrigation reported. Only 57 percent have any water monitoring programs. This includes Ft. Carson which is probably a top contender for the Army's highest water bill. It reports having a comprehensive conservation program, yet reports no monitoring.

QUESTION #10 - Who is responsible for managing water conservation programs?

RESPONSE #10 - Twenty-six percent (6 in total) of the installations reported having no one responsible for managing conservation programs. Responsibility in all designated cases was in DEH office. One installation reported a joint effort between the water plant sanitary engineer, utilities chief, energy branch, and the facilities engineer.

QUESTION #11 - What procedures or policies are implemented during water shortage or drought conditions?

RESPONSE #11 - Nine installations reported no special procedures or policies for drought. Irrigation restrictions were reported for other 15 installations with some voluntary cutback. Ft. Lewis, Washington, has a detailed four-phase water use reduction plan. Phases are associated with varying drought severity. This was by far the best water shortage contingency plan reported.

QUESTION #12 - What incentives are there in conservation programs for individuals to conserve water?

RESPONSE #12 - Ft. Bliss is the only installation mentioning an award program for conservation. None of the other installations reported having a formal incentive program. Two installations mention avoiding repercussions from commander for disregarding water use restrictions during drought as an incentive.

QUESTION #13 - Do any long-term water purchase agreements hinder installation from reducing water use?

RESPONSE #13 - None of the 25 respondents indicated any long-term agreements for water purchase that would hinder reducing water use by the installation.

QUESTION #14 - Would you favor turning over water-supply operations to a non- Federal local or regional utility if a favorable long-term contract could be negotiated?

RESPONSE #14 - One installation--Lone Star AAP, TX, which is operated by a contractor--indicated it would be more cost effective to convert to a non-Federal water supplier/operator. Ft. Leavenworth, KS, indicated that a water treatment plant is part of a commercial management package presently out for bid. Some reasons given by installations rejecting non-Federal water supply operations are: already have long-term supply contract; conflict with security needs; no non-Federal operators available; do not want to compete with other local users of water; and a remote location makes non-Federal water supply operations infeasible.

QUESTION #15 - Can installation supply quality water at a cost less than cost of buying from local utility?

RESPONSE #15 - One presently self-supplied installation indicates purchase from city may be cheaper, one indicates additional cost comparisons are close, one of these indicates potential rapid increase in future local city water supply costs could alter present close comparison. Seven installations indicate they cannot provide water at a lower cost.

QUESTION #16 - Do you think metering would save water and would metering be cost effective?

RESPONSE #16 - Only two installations (White Sands Missile Range, NM, and Yuma Proving Ground, AZ) indicated savings would be worth metering costs. Tooele Army Depot, UT indicates quarters are presently metered. All others agreed metering would save water but would not be worth the costs.

QUESTION #17 - Does your installation's Master Plan have a water supply annex? Who prepared it? Is it adequate? What time is covered?

RESPONSE #17 - Fifty-one percent (13) of the installations reported having no water supply annex. Three indicate water supply annexes are being developed. Only 40 percent of the FORSCOM and TRADOC installations reported satisfactory water supply annexes for their Master Plans. This 60 percent lack of water supply annexes appears to be a serious deficiency since these MACOM's account for the majority of troops and should experience the greatest influx of troops with any mobilization. Two (of the 10) indicate present time frame only covered in annex.

QUESTION #18 - Does your installation have adequate water supply data to develop a competent water supply plan?

RESPONSE #18 - Seventy-two percent of the responding installations (18) indicate that sufficient data is available for master planning purposes. Two installations indicate partial data available for master planning. Five indicate insufficient data.

QUESTION #19 - Where would installations obtain assistance in dealing with: surface water hydrology, ground water hydrology, legal and health problems, engineering/ technical planning, design and construction problems?

RESPONSE #19 - USACE labs are mentioned by only one installation as a source of engineering technical help. One-stop contact for all engineering/technical help may be helpful. State health agencies are primary contacts for most health-related water problems. There was mixed response on where to go for help on hydrology and legal matters and further guidance may be desirable in these areas.

QUESTION #20 - Has your installation ever obtained water withdrawal permits, etc. from non-Federal regulators. If so, specify?

RESPONSE #20 - Well permits, withdrawal declarations and surface water allocations were obtained where States regulate surface or ground water (9 of 24 responses). For example, surface water is regulated in Texas, Arizona (Colorado River), and Kansas. Ground water use permits are issued in the States of Washington and New Mexico. Allocations of these rights might be challenged. Ground water declaration is 10 times present use at White Sands Missile Range and water allocation is more than double present use at Ft. Hood, TX.

QUESTION #21 - Would your installation be able to meet water supply needs with internal (Army) resources or would outside resources be needed? (specify outsiders)

RESPONSE #21 - Where water is supplied by an outside source (Ft.Carson), resource needs and cooperative efforts needed to secure water appears unknown. Installations do not seem to have good control of their water supply situation by having full knowledge of their suppliers' water source situation. Most installations report being able to meet future needs with internal resources. Those depending on outside sources may face water supply and treatment problems over which they have limited control (Ft. Sill, for example).

QUESTION #22 - Does your installation own or control water rights within geographic boundaries? How are water rights documented? Have your water rights been challenged? Who defends installation's water rights? Are future water rights challenges anticipated?

RESPONSE #22 - Only two installations indicate forseeing a future water rights challenge. Two others indicate a possibility of water rights challenge. The variety of answers to seeking legal assistance suggests a need for more clear-cut guidance to installations.

QUESTION #23 - What are the most important areas where R&D could benefit your installations water supply?

RESPONSE #23 - Eighteen different responses have been received and only five duplications of suggested R&D needs: System corrosion control, leak prevention and repair, low cost seawater and brackish water desalinization, inexpensive metering systems, and water quality improvement. An R&D effort to develop a metering system involving little or no pipe cutting would have merit. The eighteen different suggestions for R&D are:

1. System corrosion control
2. Uses for different piping materials
3. Leak prevention and repair
4. Predictive model for pipe replacement
5. Protective coating on heat exchanger tubes
6. Ground water investigations
7. Seawater and brackish water desalinization
8. Removal of chemical contamination from ground water
9. Inexpensive metering systems
10. Water main replacement vs. rehabilitation
11. Distribution and storage
12. Reduction of lime sludge from water treatment plant
13. Alternative supply (water) for emergency
14. Use R&D for development of Master Plan
15. Study ways to reduce treatment cost of boiler feed water
16. Better water main materials
17. R&D on water treatment process to remove fluoride and other ions
18. Water quality improvement

QUESTION#24 - Are you aware of ongoing R&D within USACE to solve corrosion control and leak problems in water distribution systems?

RESPONSE #24 - Fifteen of 25 installations indicated knowledge of USACE R&D work on corrosion control and leakage problems. However, one of these installations reported having no specific information on that R&D effort. One installation mentioned other corrosion control R&D underway at its facility.

VI. ISSUES, FINDINGS, AND RECOMMENDATIONS

A. OVERVIEW

The TOR for the Subgroup discusses three broad topic areas: water policy, installation planning and operations, and R&D needs. During the course of the study, the meetings and site visits were organized to explore each of these topics with appropriate input from USACE Headquarters staff, installation DEH's and commanders, and R&D community.

Critical problem areas became apparent to the Study Group during the course of the study. They touched directly or indirectly on each of the three TOR topics mentioned in the preceding paragraph. Succinctly stated, these major concerns are:

- No appropriate legal strategy to deal with current and future water rights issues;
- Inadequate management and conservation of current resources; and
- Little planning for the future water needs of the Army.

Each of these categories is addressed below with one or more issue statements with resulting recommendations.

The Subgroup also identified another key concern adversely affecting the conduct of water planning and management. The concern relates to the institutional arrangements within USACE which make it difficult for installations to obtain the best available expert assistance necessary to solve water related problems:

- Barriers exist in cooperative working relations between the Civil Works and Military Construction personnel that hinder good water planning;
- Inconsistent levels of personnel expertise are available at the different USACE district and division offices, MACOM's, and Installations; and
- Private contractors with vastly different skill and experience levels are used for installation studies.

These institutional problems have resulted, for example, in installation water studies and master plans that range in quality from very good to very poor. It is unfortunate that this situation should exist since there is no question that the expertise is available within USACE or the private sector to produce consistently excellent study products.

The Subgroup concluded that the institutional problems are systemic, and affect far more than water resources issues. It is, therefore, beyond the scope of work for the Subgroup to fully address them.

Although the Subgroup made no attempt to examine problems unique to Eastern installations, most of the Western problems (with the exception of water rights and certain legal issues) are generic in nature. Therefore, as a final observation, many of the following issues and recommendations should be considered as applicable to all Army Installations and not just the Western United States.

B. SPECIFIC ISSUES AND RECOMMENDATIONS

Issue 1: Water Rights and Legal Policy

FINDINGS:

In the Western States, water rights are a complicated and contentious issue. Each State has separately developed its own system of water laws and regulations governing the allocation and use of surface and/or ground water, and this legal framework varies significantly from one State to another. Installation personnel involved with local water rights and permit issues appear to be faced with a lack of clear Army policy guidance, inadequate lines of legal authority and responsibility, and insufficient expertise in water law.

A review by the Subgroup of Army policy pertinent to compliance with state water law disclosed only one regulation, Acquisition of Real Property and Interests Therein (AR 405-10), May 1970 that addresses this issue. Paragraph 1-5, subparagraph (g) states:

> "It is Department of the Army policy to use unappropriated and non-navigable water upon or under lands under its jurisdiction in a manner that is in accord with the water laws which have been enacted by several States."

HQUSACE legal personnel asked to investigate the origin of this statement are uncertain as to how it is to be interpreted. In fact, a memo provided to the Subgroup by USACE legal counsel says that "the statement does not indicate that the Army will comply with State water law or in some fashion make its water use subject to State water law." This interpretation, coupled with apparent confusion at the installation level over Army policy, has led the Group to conclude that there is no meaningful policy guidance in effect to help responsible military officers decide how to deal with local water rights issues.

Further compounding this problem is the lack of a clearly-perceived chain of command for making water rights decisions. Thus, it is unclear whether Department of Justice personnel in the Lands Division, JAG personnel, or USACE personnel ought to be involved in rendering legal advice on these matters. Within USACE, water law issues have ended up in either the Office of Counsel or the Real Estate Office (Div. Br.). Neither appears to have a clear mandate for responsibility until the issue becomes a court case, at which time the Office of Counsel takes over (provided the issue was referred to USACE in the first place). The vacuum created by this uncertainty has led to personality-specific ad hoc solutions at different bases.

It is generally found that installation JAG offices have little expertise in water law. At some installations, neither the JAG or DEH staffs understood the importance of maintaining records to protect a water right, what records they should maintain, and how to file and retrieve records when required. The curriculum at the JAG School, in Charlottesville, Virginia does not address water law. With a lack of water law expertise, an ill-defined policy, and no clear lines of authority, it is no wonder that the Army has suffered from a fragmented and inconsistent approach to its water rights problems.

RECOMMENDATION:

Recommendation 1.1:

DA should adopt a new policy statement regarding water rights issues and the Army's responsibility in complying with State water law. This policy should set forth instruction on how water rights information should be documented and protected at Army installations.

Recommendation 1.2:

DA should adopt a policy that clearly defines the organizational responsibility (e.g. JAG, DOJ, USACE, etc.) for dealing with water rights legal issues.

Issue 2: Water Supply Planning

FINDINGS:

Master planning conducted at the installation level does not consistently address the issues of water resource supplies and requirements in a regional context. In many cases, planning appears to have stopped at the installation gate. With few exceptions, existing plans at installations are neither long range enough nor sufficiently comprehensive to merit identification as being "master plans" from a water resources management standpoint. Fifty-one percent of installations surveyed reported that their master plan does not include a water supply annex. Frequently master plans simply equate future water requirements with planned construction and do not consider factors such as the availability of water.

Some installations buy water, while others produce their own. Such decisions appear to have been based primarily on perceived short-term economics. Long-term management and life cycle cost considerations may, in fact, outweigh short-term costs.

Master Planning for Army Installations (AR 210-20, 12 Jun 87) does not cover water supply sources as a planning issue for installations that are either internally or externally supplied. Water is mentioned only within the context of water quality management and water supply infrastructure (utilities). AR 210-20 (para 4-6 b. Utilities Plan) references Technical Manual (TM) 5-813-1, July 1965, Water Supply, General Considerations. This TM and TM 5-813-2 deal primarily with infrastructure design and water quality considerations. TM 5-813-2 does state that quantity availability is a selection criterion for a water source and lists references for conducting such evaluations. The TM 5-813 series provides some guidance for evaluating water availability and for planning transmission, treatment, storage, and distribution facilities, but it was compiled in 1958 and has not been updated. Some guidance for

expansion of existing systems is provided by EM 1110-3-161 (April 84) Engineering and Design: Water Supply, Water Sources, Mobilization Construction. It is the only reference found which lists the importance of considering State water laws. It is not referenced in the current AR 210-20, and it is only applicable to USACE field operating agencies.

The previous AR 210-20 (26 January 76) does specifically state, "Identify and analyze the water adequacy in the analysis of existing facilities/environmental assessment report" (2-4(c), 2.c.) and "plans for future development" (3-4(c), 2.c.). It appears that comprehensive water planning has been demephasized in the current version of AR 210-20.

Existing master plans seldom evaluate water issues under worst case scenarios. Sustained full-scale mobilization would appear to constitute a potential worst case, yet mobilization planning currently does not adequately reflect impacts on demands for water either in terms of numbers of people or altered patterns of activity. Another potential worst case is when the population at an installation increases during mobilization and then is maintained at a high level because disembarkation is delayed, perhaps indefinitely. The events prompting mobilization could also evolve into conditions where water supply issues could become critical (e.g., increased security may be needed to prevent sabotage of critical transmission or pumping facilities).

Existing master plans vary considerably in format, approach, and content. They have often been prepared independently of, rather than jointly with, or even in cooperation with local civilian authorities and agencies. Comprehensive planning requires consideration of regional military and civilian water supplies and projected requirements since there are usually physical, institutional, and/or political inter-relationships. Such planning also requires the examination of various long-term scenarios, alternative plans, and life-cycle costs.

The DA appears to have no policy encouraging active participation by representatives of Army installations as members of regional planning organizations chartered to deal with water resources problems. There appears to be no funding mechanism for installations to participate in sponsoring such organizations or for paying costs for the construction or operations of regional water supply development. The observed level of participation by the affected Army installations in regional planning groups ranged from non-participation to an active leadership role. Those installations that were actively participating were covering their costs out of their operations and management (O&M) budget, i.e., "out of their hide."

Many western Army installations are included in regional water supply "districts." The installation is a user of water and pays for its water on a metered basis. In general, the Army is a good customer until it is necessary for the district to make a capital investment to expand or improve the water system. The Army must get such funds through its Military Construction Program, a process that takes years and forces such funding to compete with all other construction requirements. If the Army is a significant user, this situation puts a large burden on the district to raise the necessary capital, even if the Army agrees to increased user fees to enable the district to recoup its capital costs.

Under EO 11490, USACE is given authority to plan for water supply resources in cases of national security emergencies. The EO covers DOD and civil water requirements. One of the products of this planning is EM 1110-3-161 mentioned previously. However, evidence of USACE providing any further assistance to military master planning was not apparent because the priorities to date have emphasized the civil planning requirements.

RECOMMENDATIONS:

Recommendation 2.1:

DA should require comprehensive water supply planning as part of the stationing and master planning process. AR 210-20 and other pertinent AR's and TM's, such as Installation Commanders Guide, DEH Management Guide, be amended to:

1. Require evaluation of the adequacy of water sources and transmission, treatment, storage, and distribution facilities.

2. Require coordination to the extent possible with regional planning agencies and local utilities and encourage installation personnel to participate in appropriate regional planning groups, water districts, etc.

3. Require consideration of alternative plans, including water purchase alternatives and the integration of installation and local water systems. Explore the use of private financing techniques such as those developed recently for Army housing and electric power cogeneration to promote such integration of installations and local systems.

4. Require consideration of life-cycle costs for alternative plans.

Recommendation 2.2:

DA should develop appropriate policy guidelines and funding options that define circumstances in which installation can participate in a regional planning organization and share in the construction and operation costs of regional water projects that will benefit the installation. This study should include consideration of using private sector capital as an element of funding.

Recommendation 2.3:

USACE should prepare a guide for water resources planning and distribute it at the installation level throughout CONUS. At a minimum, it should provide improved guidance on evaluating available supplies; transmission, treatment, storage, and distribution facilities; and requirements under various scenarios, including mobilization. Projections of supplies and requirements should be long-term--at least 25 years. (The TM 5-813 series should be updated and the scope expanded considerably.) These future water supply projections should be intergrated into the long-range stationing process and utilized by stationing decision makers.

Guidance should emphasize that installations independently examine regional planning activities to assure the future availability of water even if they obtain water from civilian agencies or non-Federal utilities. They should independently confirm estimates of both the availability of water, regional usage patterns, and anticipated costs of water. The current and future limiting factors in the water supply system (e.g., the capacities of a reservoir or aquifer, the availability of water rights, or capacities of the transmission, distribution, and treatment systems) should be identified. Projections of requirements should reflect consideration of cost and conservation in water-short areas and should not be limited to using simple rules of thumb, such as 150 gallons per capita per day. The document should also provide guidance for developing conservation and contingency plans for operations under emergency conditions, such as drought, contamination, and mobilization. The numerous reports on these topics prepared by IWR and CERL provide a starting point.

Recommendation 2.4:

Based on its authority under EO 11490. USACE should assist installations in mobilization master planning with specific attention to regional contingency water planning.

Issue 3: Water Use Management and Water Conservation on Installations

FINDINGS:

Installations are not consistently managing the use of water effectively, potentially degrading the value of public assets. There are no compelling incentives at the installation level for conserving water or saving money spent for water use. DA itself has limited policy on managing water use and conservation despite EO 12512 (April 1985) which states that all agencies shall have policies and systems of accountability that ensure effective use of real property.

Although water is apparently not considered real property by the DA, it is a resource contributing to the value of real property. The only DA or USACE policy statement found on managing water use and conservation was in AR 200-1 Environment Protection and Enhancement (15 Jun 82). Chapter 3, Water Resource Management Program, section 3-3 (Policy) states, "Conserve all water resources," but provides no detailed guidance about water management and conservation. The thrust of section 3-3 is the protection of water from various forms of pollutants. Section 3-4 does give the Chief of Engineers the responsibility to issue "policy and regulations on DA water resources management."

Although it seems self-evident that water conservation is sound policy, especially in the Western States, four of the installations surveyed reported that they had no conservation program whatsoever, and none of them indicated any assessment of the effectiveness of the limited programs instituted. Water conservation is apparently stressed only when water is in short supply.

Furthermore, the survey results indicate that frequently there is no clear delineation of the individuals responsible for managing water conservation programs, setting conservation goals, publishing implementation procedures, or quantifying results. Twenty percent of the installations surveyed reported having no one specifically responsible for managing conservation.

The view by most at the installation level appears to be "water is a necessity of life; we must and will fulfill our requirements; we will budget for whatever that costs." Unfortunately there is little evidence that aggressive water conservation programs are seen as a way to preserve water for future use or as a potential source of dollar savings that could be applied to reduce budgets or applied to fulfill other needs.

Installations are not routinely and consistently performing mass balance calculations to estimate system losses, to identify excessive uses, or to evaluate conservation programs that are in place. Only 57 percent of the installations surveyed reported the use of average aggregate water use data to compare current usage levels to past levels to identify high and possibly excessive levels. No installation reported the use of average use data to evaluate a conservation program by comparing use levels after implementation of the program to use levels beforehand.

One reason typically given as justification for the lack of mass balance analyses is that adequate metering systems are not in place and that the expense of installing such systems is viewed as being beyond the means or budgets of authorities at the installation level. This reasoning appears to be based on the incorrect assumption that metering necessarily implies the use of meters at all end users, including individual quarters. The prospects of such extensive metering are viewed negatively by local managers and consumers since it is likely to be perceived as a forerunner of water charges.

With few exceptions, authorities at the installation level are not even using the limited data that are available, along with estimates of missing information, as the basis for rough mass balance calculations. Often excessive usage levels and system losses can be identified by comparing estimates of reasonable usage levels to estimates of average flows into the installation distribution system.

Installations are also not consistently making estimates of the cost of incremental water use. Eliminating excessive use can reduce numerous costs such as those for pumping, water treatment, and wastewater treatment.

RECOMMENDATIONS:

Recommendation 3.1:

DA should develop, implement, and enforce policies requiring installations to have a program for managing water use and conservation. To be a leader requires DA to adopt a program at each installation at least as good as that of the nearby civilian areas, whether they are civilian residential areas with similar socioeconomic characteristics, or facilities such as car washes, irrigated public areas, and golf courses.

Recommendation 3.2:

USACE should develop and provide to installations a model water use management and conservation program for implementation at the installation level, drawing on existing IWR and CERL reports and the R&D efforts discussed under Issue 5.

Recommendation 3.3:

DA should review budgeting and funding procedures to determine how cost savings from effective water management can be made available for installation use for other purposes. If such flexibility does not exist, installations do not have direct incentives for cost efficiency.

Recommendation 3.4:

Installations should monitor water use and the cost of incremental use levels. Mass balance calculations should be routinely made to identify excessive use and to evaluate conservation programs. Installations should determine and install an appropriate metering program(see following recommendation) to support mass balance calculations and cost evaluations. Meters may not be practical for all end users, but they could be placed so zones of relatively homogeneous users can be monitored.

Recommendation 3.5:

USACE should develop and provide guidelines for determining an appropriate metering plan for each unique installation drawing on the R&D effort discussed under Issue 5. The guidelines should deal with both existing and planned installations.

Issue 4: Institutional Impediments

FINDINGS:

Organizational expertise on water issues varies significantly at the installation level, not only in terms of assigned staffs, but also as to the availability of assistance from outside agencies, including USACE. At any given installation, the DEH is delegated responsibility to carry out real property management activities, which he does with his staff organization. However, the DEH's staff may or may not include people who are experienced in water management. In fact, there is little similarity between installations in terms of where water management expertise might be found. Water issues tend to migrate toward individuals and organizations based on personal knowledge, local history, politics, and short-term needs of commanders. It follows that water issues are managed in a variety of ways from installation to installation. The periodic rotation of knowledgeable military or civilian personnel further complicates this situation.

At some installations, officials from other Federal agencies (Bureau of Reclamation, DOJ, for example) play key roles in the management of water issues. State and local governments, local agencies, boards, and commissions may also be influential. Of particular note were observed examples of both the influence and the lack of influence shown by USACE district personnel involved in water issues. Confusing lines of responsibility with respect to support to installations often leave them seeking assistance from an office not always suitably equipped to handle the particular problem. This observation applies to technical, legal, policy, and planning issues between installations and USACE, and within echelons of USACE itself.

In summary, organizational roles and responsibilities in the field of water management are not clear cut. This is the case within the Army and USACE and applies as well to their interfaces with external agencies.

The transfer of information (technical, legal, policy, etc.) among offices to solve water related issues is inadequate. This phenomenon was apparent even within the same district between the civil and military sides, the office of counsel and real estate, or almost any two organizations that could be dealing with the same issue. As previously discussed in Issue 1, expertise in the legal area and the organizational authority and responsibility, appears to be the area most fragmented and least organized.

Technology transfer between the R&D community and installations appears inadequate even though the Construction Engineering Research Lab (CERL) and Waterways Experiment Station (WES) advertise their capabilities and products. Site visits indicated that DEH's were aware of CERL and WES but they and/or their staffs had limited appreciation of how to reap the benefits of R&D efforts over the long term.

In addition, not only are the roles and responsibilities unclear and expertise lacking, but installations and probably USACE districts and divisions (this was not investigated in any detail) are not staffed to deal with water supply issues in a regional context. This leaves the Army ill-equipped in an environment in which, as one official put it, "More and more, local governments are going to be telling the Army how to behave."

RECOMMENDATIONS:

Recommendations 4.1

DA and USACE should define the roles and responsibilities for water issues. Because circumstances vary greatly from installation to installation, caution must be exercised in developing a set of roles and responsibilities applicable to all installations. A holistic team approach should be developed that best supports the installation in a regional context. This is an area that deserves further study and careful consideration. Not only are clearly defined and articulated R&R's necessary to provide a total response to water issues, but installation-specific guidance should be developed. This guidance should cover such matters as interfacing with other Federal agencies; interfacing with State and local agencies, boards, and commissions; what constitutes a "local cooperation agreement" (as found in AR 210-70); assisting in determining where to go for help on water issues (technical, legal, policy, etc.); and developing record keeping systems that can maintain water use and rights documents for long periods of time.

Recommendation 4.2

DA should ensure that its various schools and courses (JAG, Engineer Officer Basic and Advanced Courses, DEH, Installation Commanders, Master Planning, etc.) espouse proper water management as being essential to meet the long term needs of the Army. Good water management entails the use of legal, technical, policy, planning, and research and development fields to deal with the issue. School curricula and course syllabi should be received to ensure that the student is given an appropriate amount of knowledge in these areas. The complexity of water management at certain installations merits special preparation of selected command, engineer (DEH and USACE) and legal (JAG and USACE) personnel prior to assignment at such installations (or USACE districts and divisions).

Recommendation 4.3

Information transfer, including technology transfer, must be improved in order to capitalize on the benefits derived from the previous recommendations. In regards to the specifics of technology transfer between R&D community and its beneficiaries USACE should study ways to market its R&D capabilities. Some approaches could include articles in publications like Army, Military Engineer, Airforce, Soldiers, etc., as well as private sector publications like Engineering News Record, etc. It appears there needs to be some emphasis placed on exploring ways to make technology transfer more systematic and accountable. Currently, there is too much dependence on chance.

Issue 5: Research and Development

FINDINGS:

A lengthy list of general R&D issues potentially important to DA installations was prepared by USACE personnel from HQUSACE-R&D, CERL, and WES, and reviewed by IWR. This list is resonably consistent with the broad range of R&D issues potentially important to the Nation as a whole. Numerous Federal and State agencies, as well as research institutions, are addressing these issues. There are over 35 Federal agencies alone supporting water-related research. There is no indication any of the general research issues is significantly more critical to DA than to other segments of society.

Some R&D issues, however, have aspects somewhat unique to military installations. Two specific examples of potentially important areas for R&D related to DA installations are:

1. Water use management and water conservation under conditions on military installations where greater centralized control is available than in similar nearby civilian area

2. Optimal design of water metering systems for military installations where the purpos is water use management (as opposed to providing information for billing individual user by civilian utilities or agencies).

Some R&D work related to military installations has been carried out by CERL on estimating water use levels; water conservation, recycle, and reuse; water demand forecasting; leak detection; and emergency water supply planning. At least 11 technical reports were prepared on these topics since 1981. Additional studies completed by IWR address these problems in the civilian context and are also applicable to some military problems. They provide a basis for future work.

RECOMMENDATIONS:

Recommendation 5.1:

DA should support research programs in other agencies, such as USDI, USEPA, NOAA, USDA, NSF, and DOE, which address general water-related R&D issues important to DA installations. DA should not attempt to duplicate research on the wide range of general issues important to the entire Nation. As a minimum, DA support for other agencies should include explicit endorsement of these programs during appropriations hearings.

Recommendation 5.2:

Model planning studies should be undertaken at installations in water-short areas. They should illustrate an assessment of water sources, capacities of facilities, and projected needs under various scenarios, including mobilization. These studies could be used in developing guidance for water resources planning discussed in Recommendation 2.3.

Recommendation 5.3:

Illustrative water use management and conservation programs should be undertaken at installations in water-short areas or at installations where water costs are high. Emphasis should be on mass balance calculations, optimal level of metering, calculation of incremental cost, monitoring and assessment of water conservation practices, and life-cycle cost implications of multiple funding mechanisms. These model programs could then be used by other installations.

VII. CONCLUDING REMARKS

1. The preceding findings and recommendations represent the major conclusion that evolved during the course of the Subgroup's investigation. Although these recommendations are numerous, it is the consensus of the Group that several of them are particularly important and deserving of immediate attendion:

- Adopt and implement a consistent policy towards water rights issues, with well-defined lines of organizational legal responsibility.
- Improve the installation planning process as it relates ot water supply sources and regional solutions to water problems.
- Implement improved water use management and conservation practices at Army installations.

2. While the group recognizes that the manner in which any of its recommendations may be implemented is best determined internally within the Army, it offers the following suggestions and guidance:

- Many of the findings and recommendations have broad relevance throughout CONUS, and the Group suggests that they should be applied accordingly.
- Similarly, many are relevant to other military land government installations and property. The Army may therefore wish to consider the distribution of this report within DOD and to others selected Federal agencies.
- The Group notes that their findings and recommendation cut across broad functional and organizational lines. Accordingly, the subgroup suggests that the Army staff should provide for a team approach (inter-MACOM) as a basic part of any implementation strategy or plan.

3. As with any ASB Ad Hoc Study, time constraints precluded an exhaustive examinaition of all potential issues and problems. The Group therefore concludes, based on the results of this study, that the Army should consider the following futher study efforts.

- The hydrology and legal/institutional/social framework in the Eastern United States may pose a uniquely different set of problems for Army installations in this region. This may warrant additional study.
- The Subgroup's limited consideration of water resources R&D at USACE laboratories provided a brief overview of their capabilities. Although the Group's general impressions are favorable, it believes that a more indepth study of the USACE laboratories would be useful to USACE. This could be accomplished through the ASB's laboratory external effectiveness review process which has been valuable to other Army labs.

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX A
TERMS OF REFERENCE

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, DC 20310-0103

4 FEB 1987

Dr. Irene C. Peden
Chair, Army Science Board
8752 Sand Point Way, NE
Seattle, Washington 98115

Dear Dr. Peden:

Please appoint an Army Science Board Ad Hoc Subgroup of 6-9 members to conduct a study of water problems and research needs as they relate to Army installations in the Western United States. An appropriate name for the panel would be "Ad Hoc Subgroup on Water Supply and Management for Installations in the Western United States."

Water is a strategic resource for the Army, and is essential to industrial processes, military operations, and installation support. Availability of water in the Western United States is a critical factor in installation operations, expansion planning, and future stationing decisions. Existing and potential water supplies, both surface and groundwater, will be increasingly threatened by pollution, overusage, and conflicting demands. Engineered solutions for ensuring an adequate supply will be expensive and technically complicated to implement.

A wide range of institutional arrangements govern water supply relationships between Army installations and local, state, and other Federal government entities. In many cases, western installations are supplied by local public entities, and Army's claims must compete against other public and private uses. Thus, mission requirements, quality of life on installations, and mobilization efforts could all be severely affected by drought or other conditions causing water shortages.

A general assessment of near-term and long-term problems facing Army installations in the Western United States is needed, as well as an overview of current research and development and other actions being taken to address these problems.

The scope of this review should involve the following:

- Review existing national studies (Army and others) which assess projected water availability, water quality, usage patterns, and water supply conflicts in the Western United States in the near-term (2002) and in the long-term (2037).

- Review current Department of Defense (DOD) and Army policies and procedures, and the documents resulting therefrom, for long range planning, installation master planning, and the spectrum of emergency planning, including mobilization, other national emergencies, and disaster planning, as they relate to water supply and management.

- Review for selected Army installations in the Western United States, the current water supply and management situation, including institutional arrangements.

- Review DOD, Army and non-DOD research and development activities related to installation water supply and management, with particular attention to groundwater issues such as location of sources, measurement of supply availability, drilling and extraction, and transport.

Study Group outputs:

- Provide a comprehensive assessment of near-term and long-term water supply and management issues in the Western United States as they relate to installation planning and operations.

- Recommend promising areas of research and development that the Army should pursue to address these issues, indicating those areas with greatest potential benefits and those areas of interest to the Army that are being addressed by other DOD or non-Army laboratories and institutions.

- Comment on DOD and Department of Army (DA) policies on installation water supply and management, and indicate whether they are adequate to serve near-term and long-term needs.

The Study Group should being its work on or about 26 February 1987 and should complete an interim report by 28 February 1988. Such interim report should include recommendations for further study under this Terms of Reference.

Lieutenant General E. R. Heiberg, III, Chief of Engineers, is the sponsor of the study. Mr. William Robertson, Deputy Chief Counsel, Headquarters, Office of

the Chief of Engineers is the Senior Advisor. Mr. James Waddell, Headquarters, US Army Corps of Engineers, is the Army Staff Assistant. Mr. Ronald A. Mlinarchik, Executive Director of the Army Science Board will serve as the OASA(RDA) Cognizant Deputy. The study sponsor is responsible for coordinating the Ad Hoc Study Group's work with the ASA(IL), and to keep the other HQDA Staff elements, including ASA(CW), informed.

It is not anticipated that your inquiry will go into any "particular matters" within the meaning of Section 208 of Title 18, United States Code.

Sincerely,

J. R. Sculley
Assistant Secretary of the Army
(Research, Development and Acquisition)

PARTICIPANTS LIST

ARMY SCIENCE BOARD AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT FOR
INSTALLATIONS IN THE WESTERN UNITED STATES

Study Chair
Dr. Dennis R. Horn
Assistant Professor
Department of Civil Engineering
University of Idaho
Moscow, ID 83843-4194
208-885-6818

Dr. E. Downey Brill, Jr.
Professor of Civil Engineering
& Environmental Studies
University of Illinois at
Urbana-Champaign
208 North Romine
Urbana, IL 61801-2374
217-333-8693

Dr. John W. Knapp
Dean of the Faculty
Virginia Military Institute
Lexington, VA 24450
703-463-6212

Ms. Frances J. Laidlaw
Strategic Planner
The Southland Corporation
2828 North Haskell
Dallas, TX 75204-2909
214-828-7486

Honorable Harrison Schmitt
Private Consultant
P. O. Box 14338
Albuquerque, NM 87191-4338
505-823-2616

LTG Charles J.Simmons(USA Ret.)
Private Consultant
6727 Bellamy Avenue
Springfield, VA 22152-3027
703-569-7941

Dr. James C. Smith
President of Infrastructure Group
CRS Sirrine Inc.
1177 West Loop South, Suite 600
P. O. Box 22427
Houston, TX 77227
713-552-2511

Mr. Laurence Storch
Storch & Brenner
1001 Connecticut Avenue, NW
Washington, DC 20036-5504
202-232-7080/452-0900

HQDA SPONSOR

LTG Elvin R. Heiberg, III
Chief of Engineers, US Army
CG, USA Corps of Engineers
20 Massachusetts Avenue, NW
Washington, DC 20314
202-272-0000/0001

HQDA SENIOR ADVISOR

Mr. William Robertson
Deputy Chief Counsel
Office of the Chief of Engineers
(ATTN: DAEN-CCZ-B)
20 Massachusetts Avenue
Washington, DC 20314
202-272-0018

OASA(RDA) COGNIZANT DEPUTY

Colonel Richard E. Entlich
Executive Secretary
Army Science Board
Office Assistant Secretary of
the Army (RDA)
Pentagon 2E653
Washington, DC 20310-0103
202-695-3039/7046

HQDA STAFF ASSISTANT

Mr. James Waddell*
Headquarters, US Army Corps
of Engineers
(ATTN: DAEN-CWR-S)
20 Massachusetts Avenue NW
Washington, DC 20314
202-272-0737

*Mr. Robert Wolff until 16 February 1987

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX B

WATER SUPPLY QUESTIONNAIRE

APPENDIX B
WATER SUPPLY QUESTIONNAIRE

Table of Contents

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-RS (15-8a)

6 October 1987

SUBJECT: Water Supply Questionnaire

1. I am requesting your assistance in obtaining water supply and related information from your installation. All major Army installations in the 17 Western States will receive a copy of the enclosed questionnaire which I would appreciate your completing and returning by 6 November 1987.

2. As a major water user in the Western United States, the Army must deal with a variety of water issues. To assist with these issues, an Army Science Board (ASB) Ad Hoc Subgroup on Water Supply and Management for Installations in the Western United States was formed to:

a. Provide a comprehensive assessment of near-term and long-range water supply issues as they relate to installation planning and operations.

b. Recommend areas of research and development needed to address water issues.

c. Comment on DOD and DA policies on installation water supply and management.

3. The ASB subgroup has developed the enclosed questionnaire as a major part of their study data base. If you have any questions, please call Mr. James Waddell or Mr. Charles Sargent at (202) 272-1495 or 272-1590, or Ms. Carolyn Howk at (916) 551-1288. Your cooperation and assistance in responding to the questions will be greatly appreciated. Your response should be mailed to ASB Study, c/o Charles Sargent, CEBRH-PL, Kingman Building, Ft. Belvoir, VA 22060-5576.

2 Encls
1. Questionnaire
2. Mailing List

James M. Waddell, P.E.
Army Staff Assistant

ARMY SCIENCE BOARD
QUESTIONNAIRE
TO
INSTALLATIONS

Background

1. What is your installation's source of water supply?

a. Ground water Surface water Combination
Reservoir(s)
Unregulated Streamflow

b. Self-supplied

(1) External source. Specify.
Percent of external source used by Army?

(2) Combination
Percent self-supplied
Percent outside source

2. What is your installation's water use?

a. Gal. per day average for last three years?

b. Average monthly use (in gal/day) for the last 12 months?

c. Peak day for each of last three years? (Give date and gal/day.

3. For installations using ground water (either self-supplied or external source).

a. Is ground water depletion (either quantity or quality) a problem? Explain.

b. Does your ground water source have a limited life expectancy? If so give estimated life in years, the reason(s), for the limited life, and the basis for the estimate.

4. What is the current cost (purchase contract cost) of any externally supplied water (in dollars per thousand gallons)?

a. What is your cost (in dollars per thousand gallons) of self-supplied water?

b. Indicate what costs are included for self-supply (e.g. labor, chemicals, maintenance of treatment and pumping equipment, any depreciated cost of capital investment in wells, raw-water reservoirs, and equipment).

5. What percentage of the total water consumption at your installation goes to family housing? What percentage for landscape, golf course and other irrigation?

6. What are your installation's most pressing water problems in numerical order of priority, starting with No. 1 as the most severe problem? (Specify nature of each problem.)

a. Quality of water supply source.

b. Dependability of adequate quantity for present use.

c. Inability of present water supply sources to meet any expansion needs.

d. Inadequate distribution system. Specify deficiencies.

e. Other problems(s). Specify.

7. What constraint does your installation have on water supply expansion? (Show order of priority, No. 1 being the most serious constraint.)

Inadequacy of present sources
Dependability of alternative sources
Quality of alternative sources
Legal or institutional. Specify.
Economic
Water treatment system
Transmission system
Other constraint(s). Specify

Management of Water Supplies

8. What measures or programs does your installation employ to conserve water? (Check.)

None
Metering. If so, specify extent.
Publicize need to conserve water - voluntary program
Installation of water saving devices. Specify.
Leak detection program
Recycle/reuse measures. Explain.
Other

9. How does your installation determine the effectiveness of any water conservation measures or programs?

10. Who is responsible for managing your conservation program, setting goals, determining implementing procedures, quantifying results?

11. What procedures or policies does your installation implement during water shortage or drought conditions?

12. What incentives are there in your conservation program for individuals to conserve water?

13. Do any long-term agreements for water purchase hinder your installation from reducing water use?

Water Supply Planning

14. If you now produce your own water, would you favor turning over your water supply to a non-Federal local or regional utility if you could negotiate a favorable long-term water supply contract? Discuss.

15. Do you think your installation can supply quality water at a cost that is less than the cost to buy water from a local utility? Provide basis for your answer.

16. Do you think a program to meter quarters and to charge occupants for water used would be effective in conserving water, assuming occupants would receive reasonable utilities allowance, based on family size, etc.? Do you think the savings would exceed the potential costs?

17. Does the Master Plan for your installation have a water supply annex? If so, who prepared it and what is the most recent update?

a. Do you consider the water supply annex adequate?

b. What time frame, in future years, is covered by the water supply annex?

18. Does your installation have access to adequate data to identify alternative water supplies, water demand, etc. to be able to produce a competent Master Plan?

19. Where would your installation obtain assistance in dealing with the following aspects of water supply quantity and quality problems?

Surface water hydrology
Ground water hydrology
Legal
Health
Engineering/technical planning, design, and construction of water systems, or parts thereof.

20. Has your installation ever obtained any water withdrawal permits or appropriations from non-Federal water regulators? If so, specify.

21. In meeting past or future water supply needs, has or would your installation be able to meet such needs with internal (Army) resources, or have "outside" cooperative efforts (for example with regional basin commissions) been necessary? (Specify any "outsiders.")

22. Legal Aspects

a. Does your installation own or control the water rights (ground and/or surface water) within your installation's boundries?

b. If so, how is this ownership documented?

c. Have your water rights ever been challenged?

d. Who has the responsibility to defend any challenges to your installations's water rights?

e. Do you anticipate future challenges to your water rights?

Research and Development (R&D) Needs

23. What are the most important areas where R&D could benefit your installation's water supply?

24. Are you aware of ongoing R&D within the U.S. Army Corps of Engineers to solve corrosion control and leak problems in water distribution systems?

AMC MAILING LIST

Director of Engineering and Housing/Facilities
ATTN: SDSCC-EF/Mario Lopez,
Corpus Christi Army Depot
Corpus Christi, TX 78419-6020

Director of Engineering and Housing/Facilities
ATTN: SMCMC-ISF/Don F. Jennings
McAlester Army Ammunition Plant
McAlester, OK 74501-5000

Director of Engineering and Housing/Facilities
SDSTE-NAS/1LT Warren Walker
Navajo Depot Activity
Flagstaff, AZ 86015

Director of Engineering and Housing/Facilities
ATTN: SDSTE-PUE-F/Edward B. St. Clair, Jr.
Pueblo Depot Activity
Pueblo, CO 81001-5000

Director of Engineering and Housing/Facilities
ATTN: SDSRR-AE/Charles R. Wilcox
Red River Army Depot
Texarkana, TX 75501-5000

Director of Engineering and Housing/Facilities
ATTN: SMCPM-ISF/James L. Green
Rocky Mountain Arsenal
Denver, CO 80022-2180

Director of Engineering and Housing/Facilities
ATTN: SDSSA-PANAM-WSF/Frank Moran
Sacramento Army Depot
Sacramento, CA 95813-5010

Director of Engineering and Housing/Facilities
ATTN: SDSSH-ASE-C/Robert Mustain
Sharpe Army Depot
Stockton, CA 95331-5000

Director of Engineering and Housing/Facilities
ATTN: SDSSI-FE/Andrew G. Riess
Sierra Army Depot
Herloug, CA 96113-5000

Director of Engineering and Housing/Facilities
ATTN: SDSTE-ASF/Terry B. Mathews
Tooele Army Depot
Tooele, UT 84074-5000

AMC MAILING LIST Con't

Director of Engineering and Housing/Facilities
ATTN: SDSTE-US-AS-FE/James Anderson
Urnatilla Depot Activity
Hermiston, OR 97838

GOCO

Director of Engineering and Housing/Facilities
ATTN: SMCHW-FE/Floyd Justis
Hawthorne Army Ammunition Plant
Hawthorne, NV 89416-5000

Director of Engineering and Housing/Facilities
ATTN: SMCKA-EN/Don Dailey
Kansas Army Ammunition Plant
Parsons, KS 67357-9017

Director of Engineering and Housing/Facilities
ATTN: SMCLS-EN/Madison Bagley
Lone Star Army Ammunition Plant
Texarkana, TX 75505-9109

Director of Engineering and Housing/Facilities
ATTN: SMCLO-EN/Don Maley
Longhorn Army Ammunition Plant
Marshall, TX 75670-1059

Director of Engineering and Housing/Facilities
ATTN: SMCRB-FR/Don Keith
Riverbank Army Ammunition Plant
Riverbank, CA 95367-0678

AMC-TEC

Director of Engineering and Housing/Facilities
ATTN: STEDP-FS/MAJ David F. Shockey
Dugway Proving Ground
Dugway, UT 84022-5000

Director of Engineerng and Housing/Facilities
ATTN: STEWS-IS/COL Milton L. Howell, Jr.
White Sands Missile Range, NM 88002-5031

Director of Engineering and Housing/Facilities
ATTN: STEYP-FE/Bruce S. Dobbs
Yuma Proving Ground
Yuma, AZ 85365-9102

ISC

Director of Engineering and Housing/Facilities
ATTN: ASH-DEH/LTC Roy L. Stonecipher
Fort Huachuca, AZ 85613-6000

Mailing List

U.S. Army Training and Doctrine Command
ATTN: ATEN-F/COL Bob Frink
Fort Monroe, VA 23651

U.S. Army Forces Command
ATTN: AFEN-FDI/Ron Nichols
Fort McPherson, GA 30330-6000

Director of Engineering and Housing
4th Infantry Division (Mech)
ATTN: AFZC-FE-ENR/Tom Warren
Fort Carson, CO 80913-5000

Director of Engineering and Housing
3rd Corps
ATTN: AFZF-DE-ADO/LTC Verhine
Fort Hood, TX 76544-5000

Director of Engineering and Housing
ATTN: AFZG-DE-EM/Dick Strimel
Fort Sam Houston, TX 78234-5000

Director of Engineering and Housing
1st Corps
ATTN: AFZH-EHU/Dave Hanke
Fort Lewis, WA 98433-5000

Director of Engineering and Housing
7th Infantry Division
ATTN: AFZW-DE-PD/Joe Cochran
Fort Ord, CA 93941-5000

Director of Engineering and Housing
National Training Center
ATTN: AFZJ-EHE-M/Vance Johnson
Fort Irwin, CA 92311-5000

Director of Engineering and Housing
1st Infantry Division (Mech)
ATTN: AFZN-DE-O/George Rads
Fort Riley, KS 66442-5000

Director of Engineering and Housing
ATTN: ATZC-DEH/Jim W. Conyers
Fort Bliss, TX 79916

Director of Engineering and Housing
ATTN: ATXL-GEH/Bruce A. Brotnov
Fort Leavenworth, KS 66027

Director of Engineering and Housing
ATTN: ATZR-ER/D.J. Hergenrether
Fort Sill, OK 73503

QUESTION #1 - Source of Water Supply

1. Ft. Carson, CO	Purchases water from city with combination sources
2. Ft. Hood, TX	Own reservoir storage; local treatment purchased
3. Ft. Sam Houston, TX	Self-supplied Ground Water (GW)
4. Ft. Lewis, WA	Self-supplied GW and surface water (SW)
5. Ft. Ord, CA	Self-supplied GW switching to comb. external source
6. Ft. Riley, KS	100% GW
7. Ft. Bliss, TX	70% Self-supplied GW 30% outside source
8. Ft. Leavenworth, KS	Self-supplied GW
9. Ft. Sill, OK	SW outside source
10. McAlester AAP, OK	Self-supplied SW
11. Navajo Depot Activity, AZ	Self-supplied GW
12. Red River AD, TX	Self-supplied SW
13. Rocky Mountain, Arsenal, CO	SW outside source
14. Sacramento AD, CA	Purchase from municipal system; municipal source unknown
15. Sharpe AD, CA	Self-supplied GW
16. Sierra AD, CA	Self-supplied GW
17. Hawthorne AAP, NV	Self-supplied combination GW and SW
18. Kansas, AAP, KS	Self-supplied unregulated streamflow
19. Lone Star AAP, TX	Self-supplied SW
20. Longhorn AAP, TX	Self-supplied SW
21. Dugway PG, UT	Self-supplied GW
22. Tooele AD, UT	Self-supplied SW
23. White Sands Missile Range, NM	Self-supplied GW
24. Yuma PG, AZ	Self-supplied GW
25. Corpus Christi AD, TX	Self-supplied SW and reservoir

QUESTION #3 - For Installations using Ground Water (GW)

	(a) Is depletion a problem	(b)Does ground water source have limited life expectancy?
1. Ft. Carson, CO	N/A	N/A
2. Ft. Hood, TX	Yes	Yes, will be abandoning GW
3. Ft. Sam Houston, TX	Maybe	No
4. Ft. Lewis, WA	No	No
5. Ft. Ord, CA	Yes	Yes, 20-30 years
6. Ft. Riley, KS	No	No
7. Ft. Bliss, TX	Yes	Yes, 20 to 40 years
8. Ft. Leavenworth, KS	No	No
9. Ft. Sill, OK	N/A	N/A
10. McAlester AAP, OK	N/A	N/A
11. Navajo Depot Activity, AZ	No	N/A
12. Red River AD, TX	N/A	N/A
13. Rocky Mountain, Arsenal, CO	N/A	N/A
14. Sacramento AD, CA	N/A	N/A
15. Sharpe AD, CA	No	No
16. Sierra AD, CA	Yes	Maybe
17. Hawthorne AAP, NV	Yes	Unknown
18. Kansas, AAP, KS	N/A	N/A
19. Lone Star AAP, TX	N/A	N/A
20. Longhorn AAP, TX	N/A	N/A
21. Dugway PG, UT	No	No
22. Tooele, AD UT	N/A	N/A
23. White Sands Missile Range, NM	Yes,	Unknown, Quality decline
24. Yuma PG, AZ	No	No
25. Corpus Christi AD, TX	N/A	N/A

QUESTION #5 - Distribution of Water

	% - FAMILY HOUSING and IRRIGATION
1. Ft. Carson, CO	Fam. H. 25-30%; Golf C. uses waste water
2. Ft. Hood, TX	Fam. H. 30%; Irr. 10%
3. Ft. Sam Houston, TX	Fam. H. 18%, Golf.C 20% Cemetary 10%, Landscape & Swimming Pool 3%
4. Ft. Lewis, WA	Fam. H. 29%, Landscape 39%, and Golf C. Non pot.Water
5. Ft. Ord, CA	Fam. H. 80-85%, Golf C. 7.5%, Bal Landscaping & other irrigation
6. Ft. Riley, KS	Fam. H. 20%; 1-2% other irrigation
7. Ft. Bliss, TX	Fam. H. 27%, Landscape, Golf & other irr. 9%
8. Ft. Leavenworth, KS	Fam. H. 50%, Irr. 10%, and washing fac. 15%
9. Ft. Sill, OK	Fam. H. 25% increasing to 50% in summer
10. McAlester AAP, OK	Family H. 50%
11. Navajo Depot Activity, AZ	Fam. H. 21%. and irrigation 1%
12. Red River AD, TX	Fam. H. & irrigation 2%
13. Rocky Mountain, Arsenal, CO	Unknown
14. Sacramento AD, CA	Fam. H. 5% and No information on irrigation
15. Sharpe AD, CA	Fam H. 4.3%
16. Sierra AD, CA	Fam. 20% and Landscape irr. 48%
17. Hawthorne AAP, NV	Fam. H. 20%, Landscaping & golf 30%
18. Kansas, AAP, KS	43% to residents off plant, grade school, and Kansas Gas and Electric Co.
19. Lone Star AAP, TX	Unknown
20. Longhorn AAP, TX	Unknown
21. Dugway PG, UT	Fam. H. 20%, Admin. & irr. 80%
22. Tooele AD, UT	Unknown
23. White Sands Missile Range,NM	Fam. H.24%, Grounds 15%. Golf 7%, and other 54%
24. Yuma PG, AZ	Fam. H. 55% and Irr water 75% from waste water treat. plant
25. Corpus Christi AD, TX	Unknown

QUESTION #6 - Most pressing Water Problems (In order of priority)

1. Ft. Carson, CO	Current distribution system
2. Ft. Hood, TX	Old mains & hydrants need replacement
3. Ft. Sam Houston, TX	Need add. elevated storage
4. Ft. Lewis, WA	Water quality, plumbing corrosion, & plant age for qualified staffing
5. Ft. Ord, CA	Water quality seawater intrusion, inadequate plumbing & st capacity, regional water shortage
6. Ft. Riley, KS	Water treatment & distribution sys, water quality problem
7. Ft. Bliss, TX	Ground water depletion, water quality depletion from salinity cannot meet expansion needs, ok for max of 30 yrs.
8. Ft. Leavenworth, KS	Inadequate treatment facilities
9. Ft. Sill, OK	Drought water shortage due to suppliers lack of treatment facilities
10. McAlester AAP, OK	Old distribution system
11. Navajo Depot Activity, AZ	None
12. Red River AD, TX	No problems
13. Rocky Mountain Arsenal, CO	Iron oxide from old distribution system
14. Sacramento AD, CA	Water supply source does not meet fire fighting criteria
15. Sharpe AD, CA	Old & inoperative equipment
16. Sierra AD, CA	Water quality & quantity of supply
17. Hawthorne AAP, NV	Inadequate distribution system
18. Kansas, AAP, KS	No problem
19. Lone Star AAP, TX	Age of pipes & values treatment of boiler feed
20. Longhorn AAP, TX	Age of facilities, quality of supply
21. Dugway PG, UT	Single well source, water quality
22. Tooele AD, UT	Quality of source, dependablity for present use and expansion inadequate distribution system
23. White Sands Missile Range, NM	Water quality deteriorating due to over-pumping
24. Yuma PG, AZ	Water quality distribution system, fire fighting constraint, storage & pressure, water quality
25. Corpus Christi AD, TX	Inadequate distribution system, under evaluation for replacement of main lines.

QUESTION #7 - Constraints on Water Supply Expansion (in order of priority)

1. Ft. Carson, CO	No constraints on expansion
2. Ft. Hood, TX	Economic constraint
3. Ft. Sam Houston, TX	Storage capacity for firefight, etc.
4. Ft. Lewis, WA	Need new reservoir for mobilization expansion
5. Ft. Ord, CA	Can't meet expansion needs, present supplies gone in 20 yrs Alternative water sources constrained. High future water supply improvement costs.
6. Ft. Riley, KS	Treatment system dependability, quality of sources
7. Ft. Bliss, TX	No constraints at present
8. Ft. Leavenworth, KS	Funding for treatment plant expansion
9. Ft. Sill, OK	Capacity of water treatment plant
10. McAlester AAP, OK	Capacity of water treatment plant
11. Navajo Depot Activity, AZ	Dependability of alternative sources
12. Red River AD, TX	Water treatment system constraint
13. Rocky Mountain, Arsenal, CO	No constraint
14. Sacramento AD, CA	Constraint on worst case fire demand
15. Sharpe AD, CA	Water treatment system constraint funding for infastructu improvements
16. Sierra AD, CA	No constraint
17. Hawthorne AAP, NV	Water treatment system
18. Kansas, AAP, KS	Treatment system storage capacity & transmission
19. Lone Star AAP, TX	Water treatment system constraint
20. Longhorn AAP, TX	Funding for system repair/replacement
21. Dugway PG, UT	Distribution system & water storage constraint
22. Tooele AD, UT	Transmission system, source dependability
23. White Sands Missile Range, NM	Economic constraint, inadequate present source, quality of altenative source
24. Yuma PG, AZ	Transmission system, storage, inadequate water source in s areas
25. Corpus Christi AD, TX	Economic constraint

QUESTION #8 - Water Conservation Measures

1. Ft. Carson, CO	Have comprehensive conservation program
2. Ft. Hood, TX 3.	Limited metering, recycle wash facilities, voluntary conservation program
3. Sam Houston, TX	Conservation program during drought publicizes conserv:
4. Ft. Lewis, WA	Have comprehensive conservation program
5. Ft. Ord, CA	Have comprehensive conservation program
6. Ft. Riley, KS	Some metering, water savings devices, reuse washrack
7. Ft. Bliss, TX	Voluntary program
8. Ft. Leavenworth, KS	None
9. Ft. Sill, OK	Voluntary program, leak detection program, drought prog
10. McAlester AAP, OK	Partial water conservation program
11. Navajo Depot Activity, AZ	Voluntary program
12. Red River AD, TX	None
13. Rocky Mountain, Arsenal, CO	No special program
14. Sacramento AD, CA	Publicize need to conserve water
15. Sharpe AD, CA	Voluntary program
16. Sierra AD, CA	Publicize need, water savings devices
17. Hawthorne AAP, NV	Voluntary program
18. Kansas, AAP, KS	None
19. Lone Star AAP, TX	Voluntary program, leak detection
20. Longhorn AAP, TX	Publicize need, leak detection, recycle use
21. Dugway PG, UT	Publicize need (Voluntary program)
22. Tooele AD, UT	Meter housing area, publicize need to conserve to conserve, leak detection program, receycle, reuse measures
23. White Sands Missile Range, NM	Voluntary program, police over-irrigation
24. Yuma PG, AZ	Voluntary program, install water saving devices
25. Corpus Christi AD, TX	Metering, publicize need to conserve water-voluntary pro and leak detection program

QUESTION #9 - How Installations Determine Effectiveness of Water Conservation Measures or Programs?

1. Ft. Carson, CO	None
2. Ft. Hood, TX	Monthly review of water use & inspection of units
3. Ft. Sam Houston, TX	Monitor water use record
4. Ft. Lewis, WA	Review daily consumption & unannounced visual inspecti
5. Ft. Ord, CA	Monitor daily water flows
6. Ft. Riley, KS	No effectiveness program
7. Ft. Bliss, TX	Comparison with historical use and target flows
8. Ft. Leavenworth, KS	None
9. Ft. Sill, OK	None
10. McAlester AAP, OK	N/A
11. Navajo Depot Activity, AZ	Meter readings, visual inspection
12. Red River AD, TX	None
13. Rocky Mountain, Arsenal, CO	None
14. Sacramento AD, CA	Reviewing water records
15. Sharpe AD, CA	Research by energy coordinator
16. Sierra AD, CA	Monitor consumptive data
17. Hawthorne AAP, NV	Weekly monitor daily use flows
18. Kansas, AAP, KS	None
19. Lone Star AAP, TX	None
20. Longhorn AAP, TX	Water usage review
21. Dugway PG, UT	N/A
22. Tooele AD, UT	Not known
23. White Sands Missile Range, NM	Monitor use in family housing area
24. Yuma PG, AZ	Comparison of monthly pumping/production logs
25. Corpus Christi AD, TX	None

QUESTION #10 - Who is responsible for managing the conservation program, setting goals, implementation, and qualifying results?

1. Ft. Carson, CO	Environment, Energy & Nat. Resources Div. DEH
2. Ft. Hood, TX	Environment Mgt. Office of DEH
3. Ft. Sam Houston, TX	Environment Mgt. Office of DEH
4. Ft. Lewis, WA	Joint Effort of Water Plant, Sanitary Engr. Util. Chief, Energ Br. Fac. Engr. Energy Mgmt. Br., DEH
5. Ft. Ord, CA	DEH, Engr. Resource Mgmt., Div. Energy Mgmt. Branch
6. Ft. Riley, KS	Energy Office
7. Ft. Bliss, TX	Energy Conservation Officer, DEH
8. Ft. Leavenworth, KS	Utilities Sales Officer, Energy Mgmt. Div. DEH
9. Ft. Sill, OK	None
10. McAlester AAP, OK	None
11. Navajo Depot Activity, AZ	Facilities Engineer
12. Red River AD, TX	None
13. Rocky Mountain, Arsenal, CO	Energy Coordinator
14. Sacramento A[illegible], CA	Facilities Engineer
15. Sharpe AD, CA	Energy Coordinator
16. Sierra AD, CA	DEH
17. Hawthorne AAP, NV	Manager, Facilities Management Division.
18. Kansas, AAP, KS	N/A
19. Lone Star AAP, TX	None
20. Longhorn AAP, TX	Environmental Control Dept.
21. Dugway PG, UT	N/A
22. Tooele AD, UT	Facilities Engineers
23. White Sands Missile Range, NM	DEH&L
24. Yuma PG, AZ	DEH
25. Corpus Christi AD, TX	Energy Officer

QUESTION #11 - Procedures or Policies During Water Shortage or Drought

1. Ft. Carson, CO	Water rationing
2. Ft. Hood, TX	Lawn watering restrictions
3. Ft. San Houston, TX	Drought management plans
4. Ft. Lewis, WA	Detailed 4-plan program
5. Ft. Ord, CA	Not much done
6. Ft. Riley, KS	Ask for voluntary cutbacks
7. Ft. Bliss, TX	None
8. Ft. Leavenworth, KS	MP's enforce lawn watering & vehicle wash cutbacks, rati program
9. Ft. Sill, OK	Reduce irrigation use
10. McAlester AAP, OK	None
11. Navajo Depot Activity, AZ	Restrict lawn watering & vehicle washing
12. Red River AD, TX	None
13. Rocky Mountain, Arsenal, CO	None
14. Sacramento AD, CA	Reduce lawn watering
15. Sharpe AD, CA	Restrict irrigation
16. Sierra AD, CA	Reduce lawn irrigation
17. Hawthorne AAP, NV	Restrict irrigation
18. Kansas, AAP, KS	None
19. Lone Star AAP, TX	None
20. Longhorn AAP, TX	None
21. Dugway PG, UT	Restrict irrigation
22. Tooele AD, UT	Curtail irrigation of lawns and trees
23. White Sands Missile Range, NM	Restrict irrigation
24. Yuma PG, AZ	None - Not needed
25. Corpus Christi AD, TX	Contingency plans is in place

QUESTION #12 - Incentives for Individuals to Conserve Water

1. Ft. Carson, CO	No individual incentives
2. Ft. Hood, TX	None
3. Ft. Sam Houston, TX	None
4. Ft. Lewis, WA	None
5. Ft. Ord, CA	Avoid repercussions from disregarding water use restrictio during drought
6. Ft. Riley, KS	None
7. Ft. Bliss, TX	Conservation awards
8. Ft. Leavenworth, KS	None
9. Ft. Sill, OK	None
10. McAlester AAP, OK	None
11. Navajo Depot Activity, AZ	None
12. Red River AD, TX	None
13. Rocky Mountain, Arsenal, CO	None
14. Sacramento AD, CA	None - avoid repercussions from commander for not comp with any restricitons
15. Sharpe AD, CA	None
16. Sierra AD, CA	None
17. Hawthorne AAP, NV	None
18. Kansas, AAP, KS	None
19. Lone Star AAP, TX	None
20. Longhorn AAP, TX	None
21. Dugway PG, UT	N/A
22. Tooele AD, UT	Not Known
23. White Sands Missile Range, NM	None
24. Yuma PG, AZ	None
25. Corpus Christi AD, TX	None

QUESTION #13 - Do long-term agreements for water purchase hider an installtion from reducing water use?

1. Ft. Carson, CO	No hinderence
2. Ft. Hood, TX	No
3. Ft. Sam Houston, TX	No
4. Ft. Lewis, WA	No
5. Ft. Ord, CA	No none exist
6. Ft. Riley, KS	No
7. Ft. Bliss, TX	No
8. Ft. Leavenworth, KS	No
9. Ft. Sill, OK	No
10. McAlester AAP, OK	No - supplier of water to others
11. Navajo Depot Activity, AZ	Installation has no control of water sold to non-Federal use
12. Red River AD, TX	No
13. Rocky Mountain, Arsenal, CO	No
14. Sacramento AD, CA	No
15. Sharpe AD, CA	No
16. Sierra AD, CA	No
17. Hawthorne AAP, NV	No
18. Kansas, AAP, KS	No
19. Lone Star AAP, TX	No
20. Longhorn AAP, TX	No
21. Dugway PG, UT	No
22. Tooele AD, UT	No
23. White Sands Missile Range, NM	No
24. Yuma PG, AZ	No
25. Corpus Christi AD, TX	No

QUESTION #14 - Would you favor turning over water supply to non-Federal local/regional utility favorable long-term supply contract?

1. Ft. Carson, CO	N/A
2. Ft. Hood, TX	Yes, Ft. Hood has a long-term water supply Contract
3. Ft. Sam Houston, TX	Would not trust non-Federal operator
4. Ft. Lewis, WA	No water supplier available
5. Ft. Ord, CA	Now involved in developing cooperative non-Federal oper agreement for wells at Ft.Ord
6. Ft. Riley, KS	Recent analysis showed much higher cost for non-Federal operation
7. Ft. Bliss, TX	Only non-Federal alternative for water supply managemen in best Federal interest
8. Ft. Leavenworth, KS	Water treatment plant is presently part of Commercial pac to be bid
9. Ft. Sill, OK	N/A
10. McAlester AAP, OK	Due to remoteness of installation, no non-Federal interests available to supply water
11. Navajo Depot Activity, AZ	No. May not receive water supply priority when needed.
12. Red River AD, TX	Doesen't want to compete with local users for water. Has ne modern treatment plant
13. Rocky Mountain, Arsenal, CO	N/A
14. Sacramento AD, CA	N/A
15. Sharpe AD, CA	Presently considering obtaining water from local commur
16. Sierra AD, CA	No opportunity for non-Federal operation due to remote location
17. Hawthorne AAP, NV	No, wells etc. in restricted area
18. Kansas, AAP, KS	No, security problems
19. Lone Star AAP, TX	Yes, would be more cost effective to use local supplier
20. Longhorn AAP, TX	No capable non-Federal suppliers
21. Dugway PG, UT	Not feasible because of location
22. Tooele AD, UT	No
23. White Sands Missile Range, NM	No water right problem
24. Yuma PG, AZ	No close-by non-Federal supplier
25. Corpus Christi AD, TX	N/A

QUESTION #15 - Can installations supply quality water cheaper than buying from local water util

1. Ft. Carson, CO	No, doesn't have access personnel, etc.
2. Ft. Hood, TX	No, can't do it for less.
3. Ft. Sam Houston, TX	Yes, tried to buy water, but cost excessive.
4. Ft. Lewis, WA	Yes, alternative non-Federal suppliier inadequate
5. Ft. Ord, CA	Yes, but will be going to higher cost regional system
6. Ft. Riley, KS	Cost comparisons are close, in-house supply favored
7. Ft. Bliss, TX	Yes, cost comparisons are close but future non-Federal wate supply costs are increasing rapidly
8. Ft. Leavenworth, KS	Yes, more accurate cost comparison underway
9. Ft. Sill, OK	No, contracted water supply based oncost
10. McAlester AAP, OK	Yes
11. Navajo Depot Activity, AZ	Yes, local utility twice as expensive.
12. Red River AD, TX	Yes. About $0.04/1,000 gal. less (10%) than purchasing
13. Rocky Mountain, Arsenal, CO	No
14. Sacramento AD, CA	No
15. Sharpe AD, CA	Yes
16. Sierra AD, CA	Yes
17. Hawthorne AAP, NV	No.
18. Kansas, AAP, KS	Yes, 1.6729/Kgal. vs 2.2755/Kgal from local utility.
19. Lone Star AAP, TX	No, presently self-supplied, but may be cheaper to purchase from city.
20. Longhorn AAP, TX	Yes
21. Dugway PG, UT	N/A
22. Tooele AD, UT	Information not available
23. White Sands Missile Range, NM	Yes, because of remote location.
24. Yuma PG, AZ	Yes, because of remote location.
25. Corpus Christi AD, TX	No, inadequate alternate water supply

QUESTION #16 - Would programs to meter quarters and charge occupants be effective in water conservation?

1. Ft. Carson, CO	Would save water but not worth metering costs.
2. Ft. Hood, TX	Would save water but not worth metering costs.
3. Ft. Sam Houston, TX	Would save water but not worth metering costs.
4. Ft. Lewis, WA	Would save water but not worth metering costs.
5. Ft. Ord, CA	Would save water but payback period long.
6. Ft. Riley, KS	Would save water but payback period long.
7. Ft. Bliss, TX	Would save water but payback period long.
8. Ft. Leavenworth, KS	Would save water - project 40 percent reduction in water u
9. Ft. Sill, OK	Would save water - no comment on economics.
10. McAlester AAP, OK	Would save water - no comment on economics.
11. Navajo Depot Activity, AZ	No.
12. Red River AD, TX	Would save water - no comment on economics.
13. Rocky Mountain, Arsenal, CO	Tenants already reimburse for water.
14. Sacramento AD, CA	No.
15. Sharpe AD, CA	Not applicable.
16. Sierra AD, CA	Yes, save water not cost effective.
17. Hawthorne AAP, NV	Yes, save water not cost effective.
18. Kansas, AAP, KS	N/A
19. Lone Star AAP, TX	N/A
20. Longhorn AAP, TX	N/A
21. Dugway PG, UT	N/A
22. Tooele AD, UT	No. Quarters already being metered.
23. White Sands Missile Range, NM	Yes.
24. Yuma PG, AZ	Yes, may be effective.
25. Corpus Christi AD, TX	N/A

QUESTION #17 - Does Master Planning for installtions have a water supply annex?

1. Ft. Carson, CO	Does address W.S. annex adequately
2. Ft. Hood, TX	No W.S. annex.
3. Ft. Sam Houston, TX	No W.S. annex.
4. Ft. Lewis, WA	No W.S. annex.
5. Ft. Ord, CA	No W.S. annex.
6. Ft. Riley, KS	No W.S. annex.
7. Ft. Bliss, TX	Yes, adequate, projections are for 5 and 25 yrs
8. Ft. Leavenworth, KS	Yes, 25 yrs.
9. Ft. Sill, OK	No, being updated.
10. McAlester AAP, OK	No, being developed.
11. Navajo Depot Activity, AZ	Yes, Yes, 5 yrs.
12. Red River AD, TX	Yes, Yes, but present time frame only considered.
13. Rocky Mountain, Arsenal, CO	No.
14. Sacramento AD, CA	Yes, Yes, no time frame.
15. Sharpe AD, CA	No.
16. Sierra AD, CA	No data.
17. Hawthorne AAP, NV	Yes, no timeframe.
18. Kansas, AAP, KS	No.
19. Lone Star AAP, TX	Yes.
20. Longhorn AAP, TX	No.
21. Dugway PG, UT	No, water supply covered in general document.
22. Tooele AD, UT	No. N.A. Annex
23. White Sands Missile Range, NM	Yes.
24. Yuma PG, AZ	Yes, 20 yrs.
25. Corpus Christi AD, TX	No. New plan in development.

QUESTION #18 - Does the installation have access to adequate data to identify alternative water supplies, water demand, etc. to produce competent master plans?

1. Ft. Carson, CO	Yes, master plan doesn't consider alternative water supplie
2. Ft. Hood, TX	Yes, now involved in regional water study.
3. Ft. Sam Houston, TX	Yes.
4. Ft. Lewis, WA	No data for alternative water supplies.
5. Ft. Ord, CA	Data on surface water, but ground water data lacking.
6. Ft. Riley, KS	Yes.
7. Ft. Bliss, TX	Yes.
8. Ft. Leavenworth, KS	Yes, looking at city water supply.
9. Ft. Sill, OK	Yes.
10. McAlester AAP, OK	Yes, but alternatives not required.
11. Navajo Depot Activity, AZ	Yes.
12. Red River AD, TX	Yes.
13. Rocky Mountain, Arsenal, CO	N/A
14. Sacramento AD, CA	Yes.
15. Sharpe AD, CA	No.
16. Sierra AD, CA	Yes.
17. Hawthorne AAP, NV	No alternative water suppliers in area.
18. Kansas, AAP, KS	Yes.
19. Lone Star AAP, TX	No.
20. Longhorn AAP, TX	Yes.
21. Dugway PG, UT	Yes.
22. Tooele AD, UT	Not at present
23. White Sands Missile Range, NM	Yes.
24. Yuma PG, AZ	Yes.
25. Corpus Christi AD, TX	Yes.

QUESTION #19 - Where would installations obtain assistance?

	Surface Water	Ground Water	Legal	Health	Engr/Tech
1. Ft. Carson, CO	USGS	USGS	SJA	MEDDAC	COE
2. Ft. Hood, TX	CERL, FESA A/E FIRMS		SJA	MEDDAC TX Dept. of Health	CERL, FESA A/E FIRMS
3. Ft. Sam Houston, TX	USGS Texas Water Comm., Local Water District			TX Dept. of Health	1/
4. Ft. Lewis, WA	COE	COE	COE	State DSHS	
5. Ft. Ord, CA	N/A	COE Local F.C. & Water Mang. Dist.	SJA	State & Local Health Dept.	
6. Ft. Riley, KS	CORPS OF ENGINEERS				
7. Ft. Bliss, TX	CORPS OF ENGINEERS				
8. Ft. Leavenworth, KS	A/E & COE	JAG	MEDDAC	A/E FIRMS	
9. Ft. Sill, OK					
10. McAlester AAP, OK	CORPS OF ENGINEERS				
11. Navajo Depot Activity, AZ	USFS	USFS	COE	State & County Health Dept.	MACOM
12. Red River AD, TX	A/E	N/A	COE	State Dept. of Health	COE
13. Rocky Mountain, Arsenal, CO	A/E	?			
14. Sacramento AD, CA	COE	COE	SAAD Legal Ofc.	Comm. Test Labs.	COE
15. Sharpe AD, CA	Depot Environ. Program Office		Depot Legal Ofc.	State Dept. of Health	COE

Question #19 - Cont	Surface Water	Ground Water	Legal	Health	Engr/Tech
16. Sierra AD, CA	N/A	State USGS AE Firms	COE	State	
17. Hawthorne AAP, NV	NV Div. of Health		State & COE		Desert Research Inst.-Reno
18. Kansas, AAP, KS	KANSAS STATE BOARD OF AGRICULTURE				
19. Lone Star AAP, TX	1/	1/	N/A	1/	
20. Longhorn AAP, TX	State	State	?	State	?
21. Dugway PG, UT	N/A	State USGS	JAG	State AE Firms	In-house Staff
22. Tooele AD, UT				State	
23. White Sands Missiles Range, NM	USGS	USGS A/E Firm	COE	WSMR Env. Health Ofc.	
24. Yuma PG, AZ	USGS, CERL, & COE		SJA		
25. Corpus Christi AD, TX	-	-	-	-	Consultant/ A/E-FESA

1/ Army Environmental Health Hygienist Agency.

QUESTION #20 - Has the installation ever obtained water withdrawal permits or appropriations frc non-Federal water regulators?

1. Ft. Carson, CO	No.
2. Ft. Hood, TX	Yes, allocation of 12,000 AF of reservoir storage.
3. Ft. Sam Houston, TX	No.
4. Ft. Lewis, WA	Yes, State of Washington.
5. Ft. Ord, CA	No. No ground water withdrawal or appropriation
6. Ft. Riley, KS	No.
7. Ft. Bliss, TX	No - for Texas wells. Yes - for well being developed in New Mexico.
8. Ft. Leavenworth, KS	No.
9. Ft. Sill, OK	No.
10. McAlester AAP, OK	No.
11. Navajo Depot Activity, AZ	Yes, State of Arizona.
12. Red River AD, TX	No.
13. Rocky Mountain, Arsenal, CO	No
14. Sacramento AD, CA	No.
15. Sharpe AD, CA	No, - mention State Dept. of Health & Water Quality Control Board permits.
16. Sierra AD, CA	No.
17. Hawthorne AAP, NV	Unknown
18. Kansas, AAP, KS	Yes - Kansas State Board of Agriculture.
19. Lone Star AAP, TX	No.
20. Longhorn AAP, TX	Yes - Texas Water Commission.
21. Dugway PG, UT	Yes - State of UT
22. Tooele AD, UT	No
23. White Sands Missile Range, NM	Yes - Declarations filled on wells totaling 10 times current consumption.
24. Yuma PG, AZ	Yes - Allocation of 975 AF from Colorado.
25. Corpus Christi AD, TX	No.

QUESTION #21 - Can installation meet water supply needs with Army resources or have outside cooperative efforts been necessary?

1. Ft. Carson, CO	Water needs met by outside utility.
2. Ft. Hood, TX	Yes, outside treatment facilities needed for water supply.
3. Ft. Sam Houston, TX	All needs met with internal resources.
4. Ft. Lewis, WA	Can meet needs internally but will join in cooperative effor with local community.
5. Ft. Ord, CA	Past needs met internally. Need cooperative effort for futu
6. Ft. Riley, KS	Has and will meet needs internally.
7. Ft. Bliss, TX	Have entered into cooperative studies on ground water, etc
8. Ft. Leavenworth, KS	Will have to seek supplemental water treatment by 1990, m: local city source.
9. Ft. Sill, OK	Outside cooperative effort needed since water is supplied by of Lawton.
10. McAlester AAP, OK	All needs met with internal resources.
11. Navajo Depot Activity, AZ	Yes, cooperative efforts with State of Arizona.
12. Red River AD, TX	Has and can meet needs internally.
13. Rocky Mountain, Arsenal, CO	Has and can meet needs internally.
14. Sacramento AD, CA	Water needs are met by municipal water system.
15. Sharpe AD, CA	Water needs are met by municipal water system.
16. Sierra AD, CA	No.
17. Hawthorne AAP, NV	No need for outside sources.
18. Kansas, AAP, KS	Yes, No.
19. Lone Star AAP, TX	? Army Environmental Health and Hygienist.
20. Longhorn AAP, TX	No. Water needs will be met with internal resources.
21. Dugway PG, UT	Water needs will be met internally.
22. Tooele AD, UT	No data.
23. White Sands Missile Range, NM	Present and future needs met by Army.
24. Yuma PG, AZ	Arizona Dept. of Natural Resources.
25. Corpus Christi AD, TX	N/A

QUESTION #22 - Legal Aspects

	Do you own or control water rights within a installations boundaries?	How's ownership documented?	Have water water rights been challenged?	Who has has responsibility to defend challenges of water rights?	Do you Anticipate future wate rights challenges?
1. Ft. Carson, CO	Yes	State Engineer Files	Yes	U.S. Dept. of Justice	Yes
2. Ft. Hood, TX	Yes	Auth. by Cong. State	No	SJA	No
3. Ft. Sam Houston, TX	Yes	Ground water unlimited	No	SJA	No
4. Ft. Lewis, WA	State withdrawal permits	Water rights from State	No	COE	No
5. Ft. Ord, CA	Yes	State Law	No	SJA	No
6. Ft. Riley, KS	No	Not Documented	No	COE	Possibly
7. Ft. Bliss, TX Texas New Mexico	 Yes No	 Law State Permit	 No Yes	COE	Maybe
8. Ft. Leavenworth, KS	Yes	Kansas State Law	No COE	JAG	No
9. Ft. Sill, OK	No	N/A	N/A	JAG	No
10. McAlester AAP, OK	Yes	Real Estate Documents	No Office	Legal MCAAP	No
11. Navajo Depot Activity, AZ	JAG	Yes	Yes	Permit Filed	Yes
12. Red River AD, TX	Yes	County Deed Records	No	COE	No

Question #22 - Legal Aspects (cont.)

	Do you own or control water rights within a installations boundaries?	How's ownership documented?	Have water water rights been chall-enged?	Who has has respon-sibility to defend chall-enges of water rights?	Do you Anticipate future wate rights chall enges?
13. Rocky Mountain, Arsenal, CO	Yes	Deed	Yes	U.S. Dept of Justice	---
14. Sacramento AD, CA	UNKNOWN				
15. Sharpe AD, CA	Yes Legal Ofc.	?	No	Depot	No
16. Sierra AD, CA	Yes	Not Documented	No	COE	No
17. Hawthorne AAP, NV	-	-	-	-	-
18. Kansas, AAP, KS	Yes	Vested Water Rights	No Admin-istrator	Contract	No
19. Lone Star AAP, TX	Yes	COE	No	COE	No
20. Longhorn AAP, TX	Yes	Deed	No	COE	No
21. Dugway PG, UT	Yes	Filed With State	No	Dugway Legal Office	No
22. Tooele AD, UT	Yes	COE	No	COE	No
23. White Sands Missile Range, NM	No (?)	M State Engrs Office	No	COE	Yes
24. Yuma PG, AZ	Yes	Federal Water Rights	Yes	COE	No
25. Corpus Christi AD, TX	UNKNOWN				

QUESTION #23 - Important areas where R&D could benefit installation water supply. (Numbers refer to installation (for example: 1 - Ft. Carson, 24 - Yuma PG))

1. System corrosion control - 1, 11, 21
2. Uses for different piping materials - 3
3. Leak prevention and repair - 3, 1
4. Predictive model for pipe replacement - 4
5. Protective coating on heat exchanger tubes - 4
6. Ground water investigations - 5
7. Seawater and brackish water desalinization - 5, 7
8. Removal of chemical contamination from ground water - 5
9. Inexpensive metering systems - 1, 7
10. Effectiveness of water main replacement vs. rehabilization - 2
11. Distribution and storage - 6
12. Reduction of lime sludge from water treatment plant - 8
13. Alternative supply (water) for emergency - 9
14. No important areas of the water system where R&D would be beneficial - 10, 22
15. Use R&D for development of Master Plan - 12
16. Not applicable - 13, 15, 18
17. Study of ways to reduce treatment cost of boiler feed water - 19
18. Better water main materials - 23
19. R&D on water treatment process to remove fluoride and other ions - 24
20. Water quality - 16, 20, 21

QUESTION #24 - Are you aware of on gong R&D within the USACE to solve corrosion control and leak problems in water distribution systems.

1. Ft. Carson, CO	Yes. Study is at Ft. Carson.
2. Ft. Hood, TX	Yes.
3. Ft. Sam Houston, TX	Yes.
4. Ft. Lewis, WA	Yes.
5. Ft. Ord, CA	Yes.
6. Ft. Riley, KS	Yes.
7. Ft. Bliss, TX	Yes, but not provided with info.
8. Ft. Leavenworth, KS	Yes.
9. Ft. Sill, OK	No.
10. McAlester AAP, OK	No.
11. Navajo Depot Activity, AZ	No.
12. Red River AD, TX	Yes.
13. Rocky Mountain, Arsenal, CO	Yes.
14. Sacramento AD, CA	Yes.
15. Sharpe AD, CA	Yes.
16. Sierra AD, CA	No.
17. Hawthorne AAP, NV	Yes.
18. Kansas, AAP, KS	No.
19. Lone Star AAP, TX	No.
20. Longhorn AAP, TX	Yes.
21. Dugway PG, UT	No, but aware of other water quality R&D efforts.
22. Tooele AD, UT	No
23. White Sands Missile Range, NM	No.
24. Yuma PG, AZ	Yes/No.
25. Corpus Christi AD, TX	No.

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX C

LIST OF CONTRIBUTORS AND COORDINATION LETTERS

APPENDIX C
TABLE 7
ADDITIONAL CONTRIBUTORS

Additional agency and individual contributors are listed in the following tabulation. Participants are listed by general date of active participation in the study effort.

NAME	ORGANIZATION
MG Ken Withers	DAEN-ZB
Dr. Robert Wolff	CECW-RS
Bob O'Brien	DAEN-ZCF-U
Bill Shaw	DAEN-ZCF-U
Peter Lequerque	DAEN-UC
Jim Wolcott	CECW-OW
Ray Hall	DAEN-ZCM
Bill Rushing	CERD-C
James Stratta	DAEN-ZCE
Rachel James	CEEC-EI
Russell Petit	CECC-K
William Roper	CERD-C
Crystal Campbell	CECC-Z
Stan Shelton	DAEN-ZCI-P
Clemens Meyer	CERD-M
Thomas Walski	CEWES-ER
John Harrison	CEWES-EV
Lawson Smith	CEWES-GR
Garrett Sullivan	CEWES-EN-C
Ed Smith	CECEL
Laura Dwyer	CEETL
Stan Wilhelm	CEETL
Miriam Lindmuir	CEMRD-OC
George P. Dunham	CEMD-EN
Ron DeBruin	CESWD-PL-P
Tom Olson	CESWA-OC
Daniel G. Parrillo	CESPD-ED-G
Clyde Sellers	CEMRD-RE-A
Walter Deane	CEMRD
Dellon Coker	DAGA
Andrew W. Anderson	USATHAMA
John Sustar	CEESC
Roy D. Miller	USAEHA, APG, MD
K.K. Phull	USAEHA, APG, MD
Col Robert Kish	DEH; Ft. Bliss, TX
Harry D. Pruett	Texas Water Commission
John Hickerson	El Paso, TX Water Utilities
Brad Compton	New Mexico State Engr, Ofc
J.L. (Lou) Buescher	IS-N, White Sands Missile Range
COL Bob Frink	HQTRADOC
Jim Conyers	DEH; Ft. Bliss, TX
James Kemp	DEH; Ft. Bliss, TX
Raph Dohmr	Ft. Bliss, TX
Dan N. Page	Rio Grande Project, Burea of Rec.
Lewis Putman	New Mexico State Engr. Ofc.

NAME (Cont.)	ORGANIZATION
Lee Wilson	El Paso Water Utilities
Richard Champagne	CESNF
Emozene Liles	IS-G, White Sands Missile Range
John Yacid	CESND-EDM
Bill Lewis	DEH; Ft. Bliss, TX
COL Brown	DEH; Ft. Carson, CO.
Bill Davis	Ft. Carson, CO
John Hill	U.S. Dept. of Justice, Denver, CO
Wendy Weiss	CO: State Attorney General Office
Ron Nicholson	FORSCOM
Col Richard Hendrickson	Ft. Ord, CA
LTC Leo Laska	Ft. Ord, CA
LTC Bob Meyer	Ft. Ord, CA
Joe Cochran	Ft. Ord, CA
Chuck Nix	Ft. Ord, CA
Stewart Peterson	Ft. Ord, CA
Harold Field	Ft. Ord, CA
Bill Salmon	Ft. Ord, CA
Heinz Hormann	Ft. Ord, CA
Bill Hurst	County of Monetery, CA
Nick Papdakis	AMBAG
Connie Chevoya	Marina County Water Dist, CA
Fred Meurer	City of Monterey, CA
Walter Wong	County of Monterey, CA
Lance McClair	City of Seaside, CA
George Takahashi	City of Marina, CA
Ken Dement	Monterey Penisula Water Pollution
Bruce Buel	Monterey Penisula Water Management
Janet Brennan	AMBAG
Chris Smith	Harding Lawson
Jerry Snow	County of Monerey, CA
Merrit Rice	Corps of Engineers-Sacramento District
Vince DiMaggio	City of Marina, CA
Daniel Parrillo	Corps of Engineers-South Pacific Division
B.J. Miller	County of Monterey, CA
Harold MacDonald	University of Arkansas
Dwain Butler	CEWES
James May	CEWES
Tom Walski	City of Austin, TX
Steve Maloney	CECEL
Carolynn Howk	CESPK
CAPT. Vance Johnson	Ft. Irwin, CA
Joy Brown	CEBRH-PL
Vill Sasser	Ft. Sill, OK
LTC Ken Verhine	Ft. Hood, TX
John Standsak	Ft. Hood, TX
John Easterwood	Ft. Hood, TX
Leon Howard	Ft. Hood, TX

APPENDIX C
COORDINATION LETTERS
FROM DA STAFF
(Unless otherwise noted)

Letter to DAEN-ZCF-U, DAEN-RDZ-B, DAEN-CWO, DAEN-ECE, and DAEN-IM , dated 27 Jan 87, SUBJ: Army Science Board Panel on Water Supply and Management for Installations in the Western United States - w/o Encl

Letter to Waterways Experiment Station, dated 29 Jan 87, announcing and requesting coordination on the ASB.

J.R. Scully (Assistant Secretary of the Army Research, Development, and Acquisition) letter to Dr. Irene Peden, dated 4 Feb 87, to appoint an Army Science Board Ad Hoc Subgroup of 6-9 members to conduct a study of water problems and research needs as they relate to Army installations in the Western United States.

Letter to the Four Western USACE Divisions (SPD, NPD, MRD, and SWD), dated 11 Feb 87, request to provide Mr. Waddell with names of a representative from the division to attend the study group meeting on 26-27 Feb.

Letter letter to FORSCCM, TRADOC, AMC, dated 16 Mar 87, seeking participation in the Army Science Board Study on Water Supply and Management on Western Army Installations, roles and responsibilities in installation.

Letter to Mr. S.E. Reynolds (State Engineer, NM) , dated 17 Mar 87, requesting State and Local engineering officials participate in meeting on 6 Apr 87 at Ft. Bliss, TX, discussing water supply and management roles related to Army installations.

Letter to Mr. Dean Robbins (Texas Water Commision) dated 23 Mar 87, requesting State and local engineering officials to participate in 6 April 87 meeting at Ft. Bliss, TX, discussing water supply and management roles related to Army installations.

Letter to John Hickerson (General Manager, El Paso Water Utilities & Public Service Board), dated 23 Mar 87, requesting State and local engineering officials participate in meeting on 6 Apr 87 at Ft. Bliss, TX, discussing water supply and management roles related to Army installations.

Letter to Jesse Gilmer (Rio Grande Compact Commission), dated 23 Mar 87, requesting office representation at meeting on 6 Apr 87 at Ft. Bliss, TX, to insure Study Groups complete understanding of the roles of the various agencies.

Letter to Dr. Dennis Horn (Army Science Board Chairperson), dated 26 Mar 87, welcoming the Ad Hoc Study Group.

Mr. Edward Watling (Chief, Facilities Engineering Division) Memo to ASA(I&H), dated 26 Mar 87, providing memorandum of meetings held by the Army Science Board Ad Hoc Study Group on Water Supply and Managment for Installations in the Western U.S. on 26-27 Feb 87. w/o Encl

Letter to U.S. Army Forces Command , 4th Infantry Division & Ft. Carson, and 7th Infantry Division & Ft. Ord, dated 7 May 87, requesting participation by offices and Garrison Commands, principally the DEH's, on 1-3 Jun 87 meeting at Ft. Carson and Ft. Ord, on water supply and managment for installations in the Western U.S.

Letter to Mr. F. Henry Habicht II (Assistant Attorney General Land and Natural Resources Division, U.S. Department of Justice), dated 11 May 87, requesting participation of Mr. John Hill of Denver office on 1 Jun 87 meeting at Ft. Carson, Co, reference to western water laws.

Letter to Mr. B. E. Martin (Regional Director, Bureau of Reclamation, Billings, Montana), dated 12 May 87, requesting participation in meeting at Ft. Carson, Colorado, on 1 June 87 to discuss Bureaus's current constraints on supplying water to an Army installation; what it would take to overcome them; and a general impression as to what institutional arrangements are on water supply and management problems. Also, interested in what research and development activities the Bureau is undertaking in groundwater and conservation.

Letter to Mr. Jeris Danielson (Colorado State Engineer), dated 12 May 87, requesting participation on discussion of water supply and management roles related to Army installations at Ft. Carson, on 1 Jun 87.

Mr. L. R. Shaffer letter to Distribution (MG Ken Withers, W. Robertson, J. Waddell, R. Wolff, R. O'Brien, W. Shaw, P. Lequelrque, J. Wolcott, R. Hall, B. Rushing, J. Stratta, R. James, R. Petit, W. Roper, C. Campbell, S. Shelton, and C. Meyers), dated 13 May 87, follow-on of the USA-CERL/USAWES briefing to the Army Science Board Ad Hoc Study Group.

Letter to U.S. Army Engineer Waterways Experiment Station & U.S. Army Construction Engineering Research Laboratory (w/o Encls), dated 15 Jul 87, requesting the next meeting of the Army Science Board Ad Hoc Study Group be convened at WES, and also identify a POC to meet to work out an agenda effectively covering the subject matter of the ASB.

Letter to FORSCOM (Mr. Ron Nichols) & TRADOC (COL Frink) w/o Encls, dated 7 Aug 87 requesting participation of the initial meeting on the Research and Development aspects.

Memorandum for Multiple Addressees, dated 6 Oct 87, requesting assistance in obtaining water supply and related information from various installation. All major Army installaions in the 17 Western States received a copy of the questionnaire.

Memorandum to Mr. Russ Petit, dated 19 Nov 87, requesting information on two legal question that affect how installations manage water in the future.

Memorandum for the record, dated 1 Dec 87, of discussions with Terry Wilmer and David Cohen, CERE.

Memorandum 26-27 Feb 87, Meeting in Springfield, Virginia

Memorandum 6-7 Apr 87, Meeting in Ft. Bliss, Texas

Memorandum 17-18 Aug 87, Meeting at Waterways Experiment Station (WES) Vicksburg, Mississippi

Memorandum 10 Nov 87, Meeting at Ft. Hood, Texas

Memorandum 12 Nov 87, Meeting at Ft. Sill, Oklahoma

Memorandum 12 Nov 87, Meeting at Ft. Irwin, California

Memorandum 14-15 Dec 87, Meeting in IPR, Alexandria, Virginia

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX D
BIBLIOGRAPHY

BIBLIOGRAPHY

These additional sources were utilized in preparation of this report, but may not be specifically cited in Footnotes throughout the report.

1. U.S. Army Corps of Engineers, The Provisioning of Water in Emergencies: A Research Assessment Work Unit, #1411E, September 1986

2. U.S. Army Corps of Engineers, A Procedure for Evaluating Subpotable Water Reuse Potential at Army Fixed Facilities CERL Technical Report N-109, Nov 81

3. U.S. Army Corps of Engineers, A Survey of Water Demand Forecasting Procedures on Fixed Army Installations, CERL Technical Report N-85/07, Feb 85

4. U.S. Army Corps of Engineers. Distribution of Water Use at Representative Fixed Army Installations CERL Technical Report N-157, Aug 83

5. U.S. Army Corps of Engineers, Emergency Water Supply Planning for Fixed Army Installations CERL Technical Report N-86/11, Jun 86

6. U.S. Army Corps of Engineers, Preventing Water Loss in Water Distribution System: Money-Saving Leak Detection Programs CERL Technical Report N-86/05, Mar 86

7. U.S. Army Corps of Engineers, Closed-Loop Concepts for the Army: Water Conservation, Recycle, and Reuse CERL Technical Report N-85/01, Nov 84

8. U.S. Army Corps of Engineers, Users Guide: Simulation Model for Ammunition Plants; Prediction of Wastewater Characteristics and Impact of Reuse/Recycle CERL Technical Report N-152, June 83

9. U.S. Army Corps of Engineers, Water Conservation Methods for U.S. Army Installations: Volume I, Residential Usage Management CERL Technical Report N-146, Apr 83

10. U.S. Army Corps of Engineers, Distribution of Water Use at Representative Fixed Army Installations CERL Technical Report, Aug 83

11. Army Regulation, Acquisition of Real Property and Interests Therein AR 405-10, 14 May 1970

12. U.S. Army, Installation Commander's Executive Guide to Directorate of Engineering and Housing Operations DA Pamphlet 420-9, 4 August 1986

13. Mohammed T. El-Ashry and Diana C. Gibbons, Troubled Waters: New Policies for Managing Water in the American West, October 1986

14. U.S. Army, Facilities Engineering Management Handbook DA Pamphlet 420-8

15. Army Regulation, Environmental Protection and Enhancement AR 200-1 15 June 1982

16. U.S. Army Corps of Engineers, Index of Publications, EP 310-1-1

17. Water Information Center, The Brown Water Newsletter Report 1972

18. Marc Reisner, Cadillac Dessert, The American West and Its Disappearing Water 1986

19. Army Regulation, Master Planning for Army Installations, AR 210-20, 26 Jan 76 & 12 June 87

20. U.S. Army Corps of Engineers Manual, Water Supply, Water Distribution; Mobilization Construction, EM 1110-3-164, April 84

21. U.S. Army Corps of Engineers Manual, Water Supply Water Storage Mobilization Construction, EM 1110-3-163, April 84

22. Robert Dunbar, Forging New Rights in Western Waters

23. Council on Environmental Quality, Desertification of the United States, 1981

24. Department of the Army Technical Manual, Water Supply, Water Sources, TM 5-813-2, July 1965

25. Army Regulation, Master Planning for Army Installations Emergency Expansion Capability, AR 210-23, 15 October 1976 - Rescinded

26. Army Regulation, Facilities Engineering, Water and Sewage, AR 420-46, 1 July 1978

27. U.S. Army Corps of Engineers Technical Manual, Engineering and Design, Water Sources, TM 5-813-2, 2 July 1958

28. U.S. Army Corps of Engineers Technical Manual, Water Supply General Considerations, TM 5-813-1, July 1965

29. U.S. Army Corps of Engineers, Subcommittee on Urban Water Supply, The President's Intergovernmental Water Policy Task Force, Urban Water Systems: Problems and Alternative Approaches to Solutions, June 1980

30. U.S. Army Corps of Engineers, Institute of Resources, The Role of Conservation in Water Supply Planning, IWR, April 1979

31. U.S. Army Corps of Engineers, Institute of Resources, The Evaluation of Water Conservation for Municipal and Industrial Water Supply, IWR, April 1980

32. U.S. Army Corps of Engineers, Institute of Resources, Forecasting Municipal & Industrial Water Use, IWR Main System User's Guide for Interactive Processing & User's Manual, Research Report, 83R-3, July 1983

33. Kyle Schilling, Claudia Capeland, Joseph Dixon, James Smythe, Mary Vincent & Jan Peterson, The National Public Works Report on Water Resources, National Council on Public Works Improvement, May 1987

34. U.S. Army Corps of Engineers, Institute of Water Resources, Forcasting Municipal & Industrial Water Use: A Handbook of Methods, IWR Contract Report 83C-01, July 1983

35. U.S. Army Corps of Engineers, Institute of Water Resources, Emergency Water Planning for Natural & Man-made Emergencies: An Analytical Bibliography, IWR Report 87-R-6, April 1987

36. U.S. Army Corps of Engineers, Engineer Manual Water Supply General Considerations Mobilization Construction, EM 1110-3-160, April 1984

37. U.S. Army Corps of Engineers, Engineer Manual, Water Supply, Water Sources, Mobilization Construction, EM 1110-3-161, April 1984

38. U.S. Army Corps of Engineers, Engineer Manual, Water Supply Water Treatment, Mobilization Construction, EM 1110-3-162, April 1984

39. U.S. Army Corps of Engineers, Forecasting Municipal & Industrial Water Use, RR 83R-3, 1 Jan 73

40. U.S. Army Corps of Engineers, The Role of Communications Within Technology Transfer Activities of the U.S. Army Construction Engineering Research Laboratory CERL, July 1987

41. U.S. Army Corps of Engineers, Institute of Water Resources, Emergency Water Planning for Natural & Man-made Emergencies: An Analytical Bibliography, IWR Report 87-R-6, April 1987

42. U.S. Army Corps of Engineers, Drought Contingency Planning or Fixed Army Installations, CERL TR N-87/14 April 1987

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX E
GLOSSARY

GLOSSARY

ACRONYM	TITLE
AAP	Army Ammunition Plant
AD	Army Depot
A/E	Architect and Engineer Firm
AMC	Army Material Command
AR	Army Regulations
ASB	Army Science Board
CERL	Construction Engineering Research Laboratory
COE	Chief of Engineers
CONUS	Continental United States
DEH	Director of Engineering and Housing
DOD	Department of Defense
DOE	U.S. Department of Energy
DOJ	Department of Justice
EM	Engineer Manuals
EO	Executive Order
EOAC	Engineer Officer Advanced Course
EOBC	Engineer Officer Basic Course
ETL	Engineering Topographic Laboratories
ER	Engineer Regulations
FORSCOM	Forces Command
GOCO AAP	Government Owned Contractor Operated Army Ammunition Plants
GSA	General Services Agency
GW	Ground Water
HEC	Hydrologic Engineering Center
HQDA	Headquarters Department of the Army
HQUSACE	Headquarters US Army Corps of Engineers
IPR	In Progress Review
IWR	Institute for Water Resources
JAG	Judge Advocate General
MACOM'S	Major Army Commands
MCA	Military Construction Army
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
O&M	Operations and Maintenance
PG	Proving Grounds
R&D	Research and Development
SW	Surface Water
TM	Technical Manual
TOR	Terms of Reference
TRADOC	Training and Doctrine Command
USDA	U.S. Department of Agriculture
USDI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geodetic Survey
WES	Waterways Experiment Station

NOTE: Questionnaire respondents (Appendix B) sometimes used COE as an Acronym for Corps of Engineers which is used loosely as a collective term to describe both the function of HQUSACE (The MACOM) and the Chief of Engineers in his Army staff role.

ARMY SCIENCE BOARD

REPORT OF THE AD HOC SUBGROUP
ON
WATER SUPPLY AND MANAGEMENT
FOR ARMY INSTALLATIONS
IN THE WESTERN UNITED STATES

FEBRUARY 1988

APPENDIX F
DISTRIBUTION LIST

DISTRIBUTION LIST

ADDRESSEE	COPIES
OSD	
Secretary of Defense, Pentagon, Washington, DC 20301	1
Under Secretary of Defense for Policy, Pentagon, Washington, DC 20301	1
Under Secretary of Defense for Research and Engineering, Pentagon, Washington, DC 20301	1
Assistant Secretary of Defense (Atomic Energy), Pentagon, Washington DC 20301	1
Assistant Secretary of Defense (FM&P), Pentagon, Washington DC 20301	1
Deputy Under Secretary of Defense for Research and Engineering (R&AT), Pentagon, Washington, DC 20301	1
Chairman, Defense Science Board, Pentagon, Washington, DC 20301	1
Chairman, Joint Chiefs of Staff, Pentagon, Washington, DC 20301	1
Director, DNA, 6801 Telegraph Road, Alexandria, VA 22310	1
Director, DIA, Pentagon, Washington, DC 20301	1
Defense, Technical Information Center, BLDG 5, Cameron Station, Alexandria, VA 22314	12
NAVY	
Secretary of the Navy, Pentagon, Washington, DC 20350	1
Chief of Naval Operation, Pentagon, Washington, DC 20350	1
Commandant, US Marine Corps, HQS USMC, Code CMC, Washington, DC 20380	1
Under Secretary of the Navy, Pentagon, Washington, DC 20350	1
Assistant Secretary of the Navy (RE&S), Pentagon, Washington, DC 20350	1
Director, Naval Research, Development, Test, and Evaluation, (OP-098), Pentagon, Washington, DC 20350	1
Deputy Chief of Naval Operations (Manpower, Personnel & Training), Chief of Naval Personnel, (OP-01), Washington, DC 20350	1
Commanding Officer, Naval Medical Research and Development Command, Naval Medical Command, NCR, Bethesda, MD 20814	1
Director, Research, Development, Test & Evaluation, Department of the Navy, Pentagon, Washington, DC 20350	1
Naval Research Advisory Committee, 800 N. Quincy St., Arlington, VA 22217	1
Deputy Chief of Staff, Research, Development & Studies, U.S. Marine Corps, HQS USMC, Washington, DC 20380	1
Naval Facilities Engineering Command, Pentagon, Washington DC 20350	1
AIR FORCE	
Secretary of the Air Force, Pentagon, Washington, DC 20330	1
Chief of Staff, Air Force, Pentagon, Washington, DC 20330	1
Assistant Secretary of the Air Force (RD&L), Pentagon, Washington, DC 20330	1
Assistant Secretary of the Air Force, (MRA&L), Pentagon, Washington, DC 20330	1
Deputy Chief of Staff (Acquisition), (AF/AQ), USAF, Pentagon, Washington, DC 20330	1
Assistant Chief of Staff (Studies & Analysis), USAF, (AF/SA), Pentagon, Washington, DC 20330	1
Commander, Air Force Systems Command, Andrews AFB, Washington, DC 20334	1
Air Force Scientific Advisory Board, (AF/NB), Pentagon, Washington, DC 20330	1
Directorate of Engineering and Services (AF/LEE), Pentagon, Washington, DC 20330	1

DISTRIBUTION LIST (Cont'd)

ADDRESSEE	COPIES
ARMY	
Secretary of the Army, Pentagon, Washington, DC 20310	1
Under Secretary of the Army, Pentagon, Washington, DC 20310	1
Deputy Under Secretary of the Army (Operations Research), Pentagon, Washington, DC 20310	1
Assistant Secretary of the Army (Research, Development and Acquisition), Army Science Board, Pentagon, Washington, DC 20310	1
Director, Studies and Analysis , Office of the Administrative Assistant, OSA, (for Library of Congress), Pentagon, Washington, DC 20310	1
Assistant Secretary of the Army (Manpower & Reserve Affairs), Pentagon, Washington, DC 20310	1
Assistant Secretary of the Army (Installations and Logistics), Pentagon, Washington, DC 20310	1
Assistant Secretary of the Army (Financial Management), Pentagon, Washington, DC 20310	1
The Judge Advocate, Pentagon, Washington, DC 20310	1
Chief of Staff, Army, Pentagon, Washington, DC 20310	1
Vice Chief of Staff, Army, Pentagon,Washington, DC 20310	1
Director of the Army Staff, Pentagon, Washington, DC 20310	10
Deputy Chief of Staff for Operations and Plans, Pentagon, Washington, DC 20310	1
Assistant Deputy Chief of Staff for Operations and Plans, Force Development, Pentagon, Washington, DC 20310	20
Deputy Chief of Staff for Research Development & Acquisition, OASA (RDA), Pentagon,Washington, DC 20310	1
Deputy Chief of Staff for Logistics, Pentagon,Washington,DC 20310	1
Deputy Chief of Staff for Personnel, Pentagon,Washington, DC 20310	1
Chief, MANPRINT Policy Office, Research and Studies Div., ODCSPER, Pentagon, Washington, DC 20310	10
Director, Military Personnel Management, ODCSPER, Pentagon, Washington, DC 20310	1
Director, Civilian Personnel, ODCSPER, Washington, DC 20310	1
Comptroller of the Army, Office of the Secretary of the Army, Pentagon, Washington, DC 20310	1
Assistant Secretary of the Army (Civil Works), Pentagon, Washington, DC 20310	1
Chief of Engineers, Pulaski Building, 20 Massachusetts Avenue, NW, Washington, DC 20314-1000	200
Deputy Chief of Staff for Intelligence, Pentagon,Washington, DC 20310	5
The Surgeon General, Pentagon, Washington, DC 20310	1
Chief, Army Reserve, Pentagon, Washington, DC 20310	1
Chief, National Guard Bureau, Pentagon, Washington, DC 20310	1
Chief, Military History, Pulaski Building, 20 Massachusetts Avenue, NW., Washington, DC 20314-1000	1
Commander, US Army Medical Research & Development Command, ATTN: SGRD-ZA, Fort Detrick, MD 21701	1
Commander, US Army Medical Research & Development Command, ATTN: SGRD-PLR, Fort Detrick, MD 21701	1

DISTRIBUTION LIST (Cont'd)

ADDRESSEE	COPIES
ARMY (Cont'd)	
Commander, US Army Material Command, 5001 Eisenhower Avenue, Alexandria, VA 22333	5
Commander, US Army Training and Doctrine Command, Fort Monroe, VA 23651	5
Commander, USACI, Code AS-ASCO/Dr. Sheppard, Fort Huachuca, AZ 85613	1
Deputy Commander, US Army Training and Doctrine Command, Fort Leavenworth, KS 66027	5
Scientific Advisor, US Army Training and Doctrine Command, Fort Monroe, VA 23651	1
Office Deputy Chief of Staff for Combat Development, US Army Training and Doctrine Command, ATTN: ATCD-GT, Fort Monroe, VA 23651	1
Deputy Commander, US Army Forces Command, Fort McPherson, GA 30330	5
Director, Forces Management, US Army Forces Command, ATTN: AFOP-FM, Fort McPherson, GA 30330	1
Commander, 9th Infantry Division, Fort Lewis, WA 98433	2
Commander, US Army Intelligence and Security Command, Arlington Hall Station, VA 22212	5
Commander, US Army Communications Command, Fort Huachuca, AZ 85613	2
Commander, US Army Operational Test and Evaluation Agency, 5600 Colombia Pike, Falls Church, VA 22041	1
Director, US Army Concepts Analysis Agency, 8120 Woodmont Avenue, Bethesda, MD 20814	1
Commander, US Army Nuclear and Chemical Agency, Washington, DC 20310	1
Commander, US Army Foreign Science and Technology Center, 220 7th Street, NE, Charlottesville, VA 22901	1
Commander, Missile Intelligence Agency, MICOM, Redstone Arsenal, AL 35898	1
Commander, US Army Logistics Center, Fort Lee, VA 23801	1
Commandant, US Army Logistics Management Center, ATTN: AMXMC-LS, Fort Lee, VA 23801-6040	1
Commandant, US Army Management Staff Collee, Fort Monroe, VA 23651	1
Commander, US Army Research Institute for Behavioral and Social Sciences, 5 001 Eisenhower Avenue, Alexandria, VA 22333	5
Commander, US Army Research Office, P.O. Box 12211, Research Triangle Park, NC 27709	1
Director, US Army Human Engineering Laboratory, Aberdeen Proving Ground, MD 21005	3
Director, US Army Material Systems Analysis Activity, Aberdeen Proving Ground, MD 21010	2
Chief, National Science Center for Communications and Electronics, ATTN: ATZH-STF, Fort Gordon, GA 30905-5689	1
Commandant, US Army War College, Carlisle Barracks, PA 17013	3
Commandant, US Army Command and General Staff College, Fort Leavenworth, KS 66027	5
Commandant. US Army Field Artillery and School, Fort Sill, OK 73503	1
Commandant, US Army Chemical School, Fort McClellan, AL 36205	2
Commander, Chemical Research and Development Center, Aberdeen Proving Ground, MD 21005	1
Commander, Natick Research & Development Center, Natick, MA 01760	1

DISTRIBUTION LIST (Cont'd)

ADDRESSEE	COPIES
ARMY (Cont'd)	
Commander, Combined Arms Center, Fort Leavenworth, KS 66027	5
Commander, Academy of Health Sciences, ATTN: HSA-CDS, Fort Sam Houston, TX 78234	1
Commander, Eighth US Army, APO San Francisco 96301	5
Commander, Western Command, Fort Shafter, HI 96858	5
Commander-in-Chief, US Army Europe & Seventh Army, APO New York 09403	5
Commander-in-Chief, US Army Southern Command, Quarry Heights, Panama, APO Miami 34003	5
Commanding General, US Army Japan/IX Corps, APO San Francisco 96343	5
Director, CIA, Washington, DC 20505	1
Executive Director, Board on Science & Technology (BAST), 2101 Constitution Avenue, Washington, DC 20418	1
Director of Engineering and Housing/Facilities, ATTN: SDSCC-EF, Corpus Christi Army Depot, Corpus Christi, TX 78419-6020	1
Director of Engineering and Housing/Facilities, ATTN: SMCMC-ISF, McAlester Army Ammunition Plant	1
Director of Engineering and Housing/Facilities, ATTN: SDSTE-NAS, Navajo Depot Activity, Flagstaff, AZ 86015	1
Director of Engineering and Housing/Facilities, ATTN: SDSTE-PUE-F, Pueblo Depot Activity, Pueblo, CO 81001-5000	1
Director of Engineering and Housing/Facilities, ATTN: SDSRR-AE, Red River Army Depot, Texarkana, TX 75501-5000	1
Director of Engineering and Housing/Facilities, ATTN: SMCPM-ISF, Rocky Mountain Arsenal, Denver, CO 80022-2180	1
Director of Engineering and Housing/Facilities, ATTN: SDSSA-PANAM-WSF, Sacramento Army Depot, Sacramento, CA 95813-5010	1
Director of Engineering and Housing/Facilities, ATTN: SDSSH-ASE-C, Sharpe Army Depot, Stockton, CA 95331-5000	1
Director of Engineering and Housing/Facilities, ATTN: SDSSI-FE, Sierra Army Depot, Herloug, CA 96113-5000	1
Director of Engineering and Housing/Facilities, ATTN: SDSTE-ASF, Tooele Army Depot, Tooele, UT 84074-5000	1
Director of Engineering and Housing/Facilities, ATTN: SDSTE-US-AS-FE, Umatilla Depot Activity, Hermiston, OR 97838	1
Director of Engineering and Housing/Facilities, ATTN: SMCHW-FE, Hawthorne Army Ammunition Plant, Hawthorne, NV 89416-5000	1
Director of Engineering and Housing/Facilities, ATTN: SMCKA-EN, Kansas Army Ammunition Plant, Parsons, KS 67357-9017	1
Director of Engineering and Housing/Facilities, ATTN: SMCLS-EN, Lone Star Army Ammunition Plant, Texarkana, TX 75505-9109	1
Director of Engineering and Housing/Facilities, ATTN: SMCLO-EN, Longhorn Army Ammunition Plant, Marshall, TX 75670-1059	1
Director of Engineering and Housing/Facilities, ATTN: SMCRB-FR, Riverbank Army Ammunition Plant, Riverbank, CA 95367-0678	1

DISTRIBUTION LIST (Cont'd)

ADDRESSEE	COPIES
ARMY (Cont'd)	
Director of Engineering and Housing/Facilities, ATTN: STEDP-FS, Dugway Proving Ground, Dugway, UT 84022-5000	1
Director of Engineering and Housing/Facilities, ATTN: STEWS-IS, White Sands Missile Range, NM 88002-5031	1
Director of Engineering and Housing/Facilities, ATTN: STEYP-FE, Yuma Proving Ground, Yuma, AZ 85365-9102	1
Director of Engineering and Housing/Facilities, ATTN: ASH-DEH, Fort Huachuca, AZ 85613-600	1
US Army Training and Doctrine Command, ATTN: ATEN-F, Fort Monroe, VA 23651	1
US Army Forces Command, ATTN: AFEN-FDI, Fort McPherson, GA 30330-6000	1
Director of Engineering and Housing, 4th Infantry Division (Mech), ATTN: AFZC-FE-ENR, Fort Carson, CO 80913-5000	1
Director of Engineering and Housing, 3rd Corps, ATTN: AFZG-DE-ADO, Fort Hood, TX 76544-5000	1
Director of Engineering and Housing, ATTN: AFZF-DE-EM, Fort Sam Houston, TX 78234-5000	1
Director of Engineering and Housing, 1st Corps, ATTN: AFZH-EHU, Fort Lewis, WA 98433-5000	1
Director of Engineering and Housing, 7th Infantry Division, ATTN: AFZW-DE-PD Fort Ord, CA 93941-5000	1
Director of Engineering and Housing, National Training Center, ATTN: AFZW-EHE-M Fort Irwin, CA 92311-5000	1
Director of Engineering and Housing, 1st Infantry Division (Mech), ATTN: AFZN-DE-O, Fort Riley, KS 66442-5000	1
Director of Engineering and Housing, ATTN: ATZC-DEH, Fort Bliss, TX 79916	1
Director of Engineering and Housing, ATTN: ATXL-GEH, Fort Leavenworth, KS 66027	1
Director of Engineering and Housing, ATTN: ATZR-ER, Fort Sill, OK 73503	1
OFFICE OF THE CHIEF OF ENGINEERS	
US Army Engineering Topographic Laboratories, Building 2592, Fort Belvoir, VA, 22060-5546	2
US Army Engineering Waterways Experiment Station, P.O. Box 631, Vicksburg, MS 39180-0631	5
US Army Construction Engineering Research Laboratory, P.O. Box 4005, Champaign, IL 61820-1305	10
US Army Facilities Engineering Support Agency, Building 358, Fort Belvoir, VA, 22060-5516	1
US Army Engineering Automation Support Activity, P.O. Box 37520, Washington, DC 20013-7520	1
US Army Engineering Studies Center, Casey Building 2594, Fort Belvoir, VA 22060-5583	1
US Army Corps of Engineers Water Resources Support Center, Casey Building 2594, Fort Belvoir, VA 22060-5586	1

DISTRIBUTION LIST (Cont'd)

ADDRESSEE	COPIES
OFFICE OF THE CHIEF OF ENGINEERS	
Institute for Water Resources, Casey Building 2594, Fort Belvoir, VA 22060-5586	1
Hydrologic Engineering Center, 609 Second Street, Davis, Ca 95616-4687	1
Marine Design Center, US Custom House, 2nd & Chestnut Streets, Philadelphia, PA 19106-2991	1
Waterborne Commerce Statistic Center, P.O. Box 61280, New Orleans, LA 70161	1
US Army Humphreys Engineer Center Support Activity, Kingman Building 2593, Fort Belvoir, VA 22060-5580	1
Board of Engineers for Rivers and Harbors, Kingman Building, Fort Belvoir VA 22060-5576	1
Commander, US Army Engineering Division, Huntsville, P.O. Box 1600, Huntsville, AL 35807-4301	3
Commander, US Army Engineering Division, Lower Mississippi Valley, P.O. Box 80 Vicksburg, MS 39180-0080	13
Commander, US Army Engineering Division, New England, 424 Trapelo Rd, Waltham, MA 02254-9149	3
NED Water Quality Laboratory Location, Barre Falls Dam, RFD 1, Hubbardston, MA 01452-9743	3
Commander, US Army Engineering Division, North Atlantic, 90 Church Street, New York, NY 10007-9998	11
Commander, US Army Engineering Division, North Central, 536 S. Clark Street, Chicago, IL 60605-1592	13
Commander, US Army Engineering Division, North Pacific, P.O. Box 2870, Portland, OR 97208-2870	11
Commander, US Army Engineering Division, Ohio River, P.O. Box 1159, Cincinnati, OH 45201-1159	13
Commander, US Army Engineering Division, Pacific Ocean, Fort Shafter, HI 96858-5440	7
Commander, US Army Engineering Division, South Atlantic, 510 Title Building, 30 Pryor Street, SW Atlanta, GA 30335-6801	15
Commander, US Army Engineering Division, South Pacific, 630 Sansome Street, Rm 720, San Francisco, CA 94111-2206	11
Commander, US Army Engineering Division, Southwestern, 1114 Commerce Street, Dallas, TX 75242-0216	15